SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

PLANNING, RULE DEVELOPMENT, AND AREA SOURCES

ANALYSIS OF NATURAL EVENTS CONTRIBUTING TO HIGH PM_{10} CONCENTRATIONS IN THE COACHELLA VALLEY ON JULY 16, 2006

Final Report
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TABLE OF CONTENTS

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INTRODUCTION

This document substantiates the request by the South Coast Air Quality Management District (AQMD) to consider two violations of the 150 $\mu g/m^3$ PM10 24-hour National Ambient Air Quality Standard (NAAQS) the Coachella Valley portion of the Salton Sea Air Basin as natural events under the U.S. EPA Natural Events Policy. The violations occurred on July 16, 2006 at two AQMD air monitoring stations: Coachella Valley 1 (Palm Springs) and Coachella Valley 2 (Indio).

PM10 SUMMARY

On July 16, 2006, the size-selective inlet (SSI) sampler at the Indio air monitoring station measured a 24-hour PM_{10} concentration of 313 $\mu g/m^3$. An unofficial collocated SSI sampler at Indio measured 350 $\mu g/m^3$. A recent audit confirmed a tendency for this collocated sampler to measure high. SSI data from the Palm Springs air monitoring station measured 226 $\mu g/m^3$ for the same 24-hour period. The San Gorgonio Pass SSI sampler at the Banning Airport in the South Coast Air Basin only measured 47 $\mu g/m^3$; however, this sample has since been invalidated by the AQMD Laboratory due to a flow rate outside the acceptable limits. The continuous Beta Attenuation Monitor (BAM)[1] at Indio was not operational during this period while the Palm Springs BAM measured a 24-hour average PM_{10} concentration of 231.3 $\mu g/m^3$, correlating well with the SSI measurement and providing timing information for this event.

The hourly BAM data from Palm Springs is shown in Table 1, starting at 1200 PST on July 15 before the concentrations started to increase and ending at 0600 PST on July 17 after the elevated concentrations ended. Concentrations exceeding 150 $\mu g/m^3$ are highlighted in bold type. The Palm Springs BAM data indicates consistently high concentrations throughout the morning and early afternoon on July 16, with the

[1] The AQMD has only used the BAM measurements for forecasting purposes and public notification of PM_{10} events. While the U.S. EPA accepts the BAM measurements as an equivalent federal reference method, these instruments have not historically been relied upon for determining NAAQS compliance in the South Coast Air Basin or Coachella Valley.

concentrations lower in the evening, then increasing again at the end of the day. While Palm Springs is often sheltered from the blowsand by the San Jacinto Mountains during the west through northwest high-wind regimes that blow along the Coachella Valley, this is typically not the case with the southerly flow that is common during summer "monsoon" events as seen in this case. The highest hourly BAM concentrations measured during this event at Palm Springs exceeded 550 $\mu g/m^3$ in the early morning on July 16.

Hourly BAM PM10 measurements collected by the Imperial County Air Pollution Control District near the Salton Sea also showed elevated concentrations. The July 16 hourly BAM PM10 data are shown in Table 2 for the Westmoreland station, south of the Salton Sea, and the Niland station, at the southeastern edge of the Salton Sea. Westmoreland remained above 150 $\mu g/m^3$ for the first five hours of the day and Niland for the first seven hours, then both remained lower for the remainder of the day. Westmoreland peaked at 657 $\mu g/m^3$ for the hour starting at 0000 PST, while Niland peaked at 386 $\mu g/m^3$ at 0100 PST, then again at 0500 PST. Due to the short period of high concentrations, the 24-hour average was only 122.5 $\mu g/m^3$ at Westmoreland and 141.3 $\mu g/m^3$ at Niland.

In an attempt to show suspected smoke and ash impacts on July 16 from nearby wildfires, a chemical speciation analysis was performed on the PM10 SSI filters by the AQMD Laboratory. The results of this analysis (potassium, organic carbon, elemental carbon and total carbon concentrations), along with routine SSI PM10 sulfate, nitrate and chloride and SSI PM2.5 concentrations, are shown in Table 3 with available data from Riverside-Rubidoux and Downtown Los Angeles included for reference. PM10 organic carbon and PM10 potassium, as well as PM2.5 mass, were relatively high on the Indio and Palm Springs filters, as compared to the other stations, indicating a possible contribution from burning brush and ash. PM10 organic carbon was 16.7 $\mu g/m^3$ at Palm Springs and 21.8 $\mu g/m^3$ at Indio on July 16. A 1-year speciation sampler study starting in September 1988 at Palms Springs and Indio found annual averaged organic carbon concentrations of 4.27 $\mu g/m^3$ at Palm Springs and 5.68 $\mu g/m^3$ at Indio. The highest daily organic carbon concentrations measured during the study period were 8.135 and 10.042 $\mu g/m^3$ at Palm Springs and Indio, respectively[2]. This sampling period included two very high PM10 events related to strong thunderstorm outflows on July 9 and July 27, 1989. The elevated organic carbon indicates a potential for impact of the wildfire smoke and ash on this PM10 episode. That the PM10 organic carbon and PM2.5 concentration were not higher likely indicates a relatively short duration of smoke and ash impact during the 24-hour sampling period, during which windblown dust was also a factor.

[2] SCAQMD. State Implementation Plan for PM10 in the Coachella Valley. South Coast Air Quality Management District Final Report, November 1990.

PM10 potassium concentrations were higher at the two Coachella Valley stations on July 16 than at the other analyzed stations, with concentrations of 0.83 $\mu g/m^3$ at Palm Springs and 0.96 $\mu g/m^3$ at Indio compared to 0.27 $\mu g/m^3$ at Banning and 0.15 $\mu g/m^3$ at Downtown Los Angeles. The 1988-89 speciation sampler study found annual averaged potassium concentrations of 0.47 $\mu g/m^3$ at Palm Springs and 1.00 $\mu g/m^3$ at Indio, with daily maxima for the 1-year sampling study of 2.162 and 3.121 $\mu g/m^3$ at Palm Springs and Indio, respectively. Although the PM10 potassium concentrations at Palm Springs and Indio are elevated as compared to the other stations on this day, the potassium analysis does not clearly point to the wildfire smoke contributions when compared to the older study measurements. While not entirely conclusive, this speciation analysis provides support that wildfire smoke and ash could have contributed to the PM10 measured in the Coachella Valley on July 16, but that the windblown dust was likely the most important factor. It is likely that the wildfire smoke and ash only contributed in the early morning hours of July 16, when the highest BAM PM10 was measured at Palm Springs, associated with weak nighttime drainage flows that brought the smoke into the valley.

The following sections describe the meteorological setting, a summary of the nearby wildfire activity and the analysis of the events leading to high PM10 in the Coachella Valley on July 16, including windblown dust transported from afternoon thunderstorm outflows over Arizona and northern Mexico.

TABLE 1

Hourly BAM and 24-hour SSI PM_{10} Measurements at the AQMD Palm Springs and Indio Air Monitoring Stations in the Coachella Valley Between 1200 PST July 15 and 0600 PST July 17, 2006

(Note: Indio BAM PM10 was not available for this period due to operational problems.)

		Palm Springs Monitoring Station			Indio Monitoring Station	
DATE	**HOUR (PST)**	**BAM Hourly PM_{10} ($\mu g/m^3$)**	**24-Hour Average PM_{10} ($\mu g/m^3$)**		**BAM Hourly PM_{10} ($\mu g/m^3$)**	**24-Hour Average PM_{10} ($\mu g/m^3$)**
			BAM	**SSI**		**SSI**
7/15/06	1200	28			N/A	
	1300	25			N/A	
	1400	8			N/A	
	1500	9			N/A	
	1600	36			N/A	
	1700	35			N/A	
	1800	37			N/A	
	1900	40			N/A	
	2000	22			N/A	
	2100	26			N/A	
	2200	81			N/A	
	2300	**171**			N/A	
7/16/06	0000	7			N/A	
	0100	**215**			N/A	
	0200	**454**			N/A	
	0300	**553**			N/A	
	0400	**554**			N/A	
	0500	**292**			N/A	
	0600	148			N/A	
	0700	**239**			N/A	
	0800	**466**			N/A	
	0900	**275**			N/A	
	1000	**262**			N/A	
	1100	**241**			N/A	
	1200	**196**			N/A	
	1300	**194**			N/A	
	1400	**221**			N/A	
	1500	**176**			N/A	
	1600	138			N/A	
	1700	149			N/A	
	1800	115			N/A	
	1900	84			N/A	
	2000	70			N/A	
	2100	69			N/A	
	2200	69			N/A	
	2300	**363**	**231.3**	**226**	N/A	**313**
7/17/06	0000	5			N/A	
	0100	49			N/A	
	0200	**201**			N/A	
	0300	**292**			N/A	
	0400	105			N/A	
	0500	**352**			N/A	
	0600	19	77.7 (through Midnight)		N/A	

TABLE 2

Hourly BAM PM_{10} Measurements at the Imperial County APCD Westmoreland and Niland Air Monitoring Stations on July 16, 2006

		Westmoreland Monitoring Station		Niland Monitoring Station	
DATE	**HOUR (PST)**	**BAM Hourly PM_{10} ($\mu g/m^3$)**	**24-Hour Average PM_{10} ($\mu g/m^3$) BAM**	**BAM Hourly PM_{10} ($\mu g/m^3$)**	**24-Hour Average PM_{10} ($\mu g/m^3$) BAM**
7/16/06	0000	**657**		**368**	
	0100	**230**		**286**	
	0200	**293**		**326**	
	0300	**319**		**284**	
	0400	**166**		**174**	
	0500	123		**386**	
	0600	110		**175**	
	0700	69		134	
	0800	58		104	
	0900	62		120	
	1000	95		138	
	1100	108		99	
	1200	78		110	
	1300	78		102	
	1400	63		66	
	1500	59		55	
	1600	40		49	
	1700	43		48	
	1800	57		78	
	1900	45		79	
	2000	39		41	
	2100	58		27	
	2200	46		20	
	2300	45	122.5	21	141.3

TABLE 3

SSI PM2.5 and Chemical Speciation Analysis of AQMD SSI PM10 Samples for Sunday, July 16, 2006 from Palm Springs, Indio (A = routine, B = collocated), Banning Airport, Riverside-Rubidoux and Downtown Los Angeles Air Monitoring Stations

(Note that the Banning sample was invalidated since the flow rate was outside the acceptable limits)

Station	PM2.5 ($\mu g/m^3$)	PM10 ($\mu g/m^3$)	Sulfate ($\mu g/m^3$)	Nitrate ($\mu g/m^3$)	Chloride ($\mu g/m^3$)	Potassium ($\mu g/m^3$)	Organic Carbon ($\mu g/m^3$)	Elemental Carbon ($\mu g/m^3$)	Total Carbo n ($\mu g/m^3$)
Palm Springs	24.8	**226**	4.9	7.3	0.3	0.83	16.7	0.3	17.0
Indio A	24.3	**313**	5.4	6.9	1.2	0.96	21.8	0.3	22.1
Indio B		**350**				1.12	21.0	0.3	21.3
Banning Airport		47				0.27	7.4	1.2	8.6
Riverside – Rubidoux	13.8	55	5.1	4.5	0.0				
Downtown Los Angeles	12.9	33	4.3	4.5	0.0	0.15	4.6	1.7	6.3

METEOROLOGICAL SETTING

Previous natural event analyses defined three meteorological mechanisms that lead to high-wind PM10 events in the Coachella Valley[3], including: (1) strong pressure and density gradients forcing high winds through the San Gorgonio Pass, (2) storms and frontal passages, and (3) thunderstorm outflow winds. The overall meteorological conditions on July 15 and 16 were the typical "monsoonal" conditions, with stagnant high pressure aloft, hot temperatures, periods of high relative humidity, and convective activity over the mountains and deserts. These conditions were highly conducive to PM10 NAAQS violations due to the Type 3 high-wind event classification, that is, strong downbursts and gust fronts from summertime thunderstorm activity. Such convective activity produces strong downdrafts of cooler air, causing wind gusts that can exceed 60 mph. While the thunderstorms are usually localized events of short duration, the associated downbursts and outflows can suspend large amounts of natural desert soil in the atmosphere that can be transported over large distances, even though the gustiness subsides. The necessary weather pattern for producing such thunderstorms in the southwestern U.S. is one in which tropical moisture is advected into the deserts from the south and southeast. Therefore, these Type 3 events are typically associated with the mid- to late-summer "monsoonal" conditions that bring light southeasterly winds to the Coachella Valley.

Monsoonal conditions persisted through most of July 2006, bringing long periods of high pressure aloft, excessive heat and high humidity to most of the southwestern United States. The conditions were relatively stagnant overall, causing several periods of elevated ozone in the South Coast Air Basin, including some of the year's peak concentrations on July 15 and 22. Cumulus development was common over the mountains and deserts of southern California and scattered thunderstorms occurred, mostly in the afternoons and evenings. Thunderstorms ignited several wildfires. Although the light southeasterly winds dominated in the Coachella Valley, periods of onshore flow through the San Gorgonio Pass caused occasional, brief reversals, as did nighttime drainage flows. On Saturday, July 15, Indio broke its record high temperature of 117 degrees, set in 1911, registering 122 degrees. On July 16, Indio reached 115 degrees. Thunderstorm activity was prevalent throughout the southwestern U.S. in the afternoons and evenings of July 15 and 16.

[3] Durkee, K.R. The EPA Natural Events Policy as Applied to High-Wind PM_{10} Exceedances in the Coachella Valley. Proceedings of the Air and Waste Management Assn. Annual Meeting, June 1998.

WILDFIRE SUMMARY

On July 16, and for several days prior, large wildland fires impacted visibility and PM concentrations in desert and mountain areas of San Bernardino and Riverside Counties, as well as the Coachella Valley. The Millard Complex fire began in the morning of July 9 from lightning strikes in the San Gorgonio Wilderness, seven miles north of Cabazon in San Bernardino County[4]. The Millard complex consisted originally of three fires burning in steep, inaccessible terrain. Also on July 9, the Sawtooth Complex wildfire began near the community of Pioneertown, west of the town of Yucca Valley and north of the town of Morongo Valley, in San Bernardino County. This was again caused by lightning due to severe thunderstorm activity in the area. The fires burned in brush and chaparral, with Pinyon, Juniper and Jeffery Pines in the higher elevations.

On July 14 the Sawtooth and Millard fires merged. The Heart incident was established by the fire agencies to provide management of the portion of the merged Sawtooth/Millard Complex fires that moved into a new geographic area, the Onyx Peak vicinity eight miles southwest of Big Bear Lake in San Bernardino County. During much of the fire activity, the smoke and ash plume was mainly directed toward the north and east into the Mojave Desert Air Basin with relatively high plume rise. The smoke plume was reported at least as far away as Las Vegas. However, in the early morning hours of July 16, weak winds and nighttime drainage flow conditions allowed smoke to impact the Coachella Valley.

The Sawtooth Complex was 50 percent contained, as reported in the evening of July 15, with approximately 60,000 acres burned, 1 fatality, 11 injuries, 50 residences destroyed, 12 residences damaged, and 171 outbuilding destroyed. At 1800 PDT, the Sawtooth Complex command reported westerly winds at 8 mph with a temperature of 106 and 20 percent relative humidity. South winds to 15 mph were predicted for the fire lines for July 16, with only slightly cooling temperatures, increasing relative humidity and a strong threat of thunderstorms. The main fire activity with the Sawtooth Complex was near Yucca Valley at this time and the growth potential was considered extreme.

In the evening of July 15, the Millard Complex fire was only 10 percent contained with 15,572 acres involved, while the Heart fire was about 800 acres. Due to the remote nature of these fires, no injuries or building damage were attributed to the Millard and Heart fires. At 1800 PDT, the Millard Complex command reported westerly winds at 10-15 mph with a temperature of 104 and 16 percent relative humidity. West-southwest winds were predicted at the fire for July 16, with slightly cooling temperatures, increasing relative humidity and a strong threat of thunderstorms. At this time, the fire was very active in the Whitewater Canyon, north of the community of Whitewater a few

[4] Fire Information Source: Incident Status Summary (ICS-209) reports issued by the fire agency incident commanders and available from the National and Aviation Management Web Applications (FAMWEB) by the National Wildfire Coordinating Group.

miles north of the northwestern end of the Coachella Valley (north of Interstate 10 and west of Highway 62). It was primarily burning toward the northeast with extreme growth potential. Figure 1 shows an overall map of the fire area and a map of the daily fire progression through July 16.

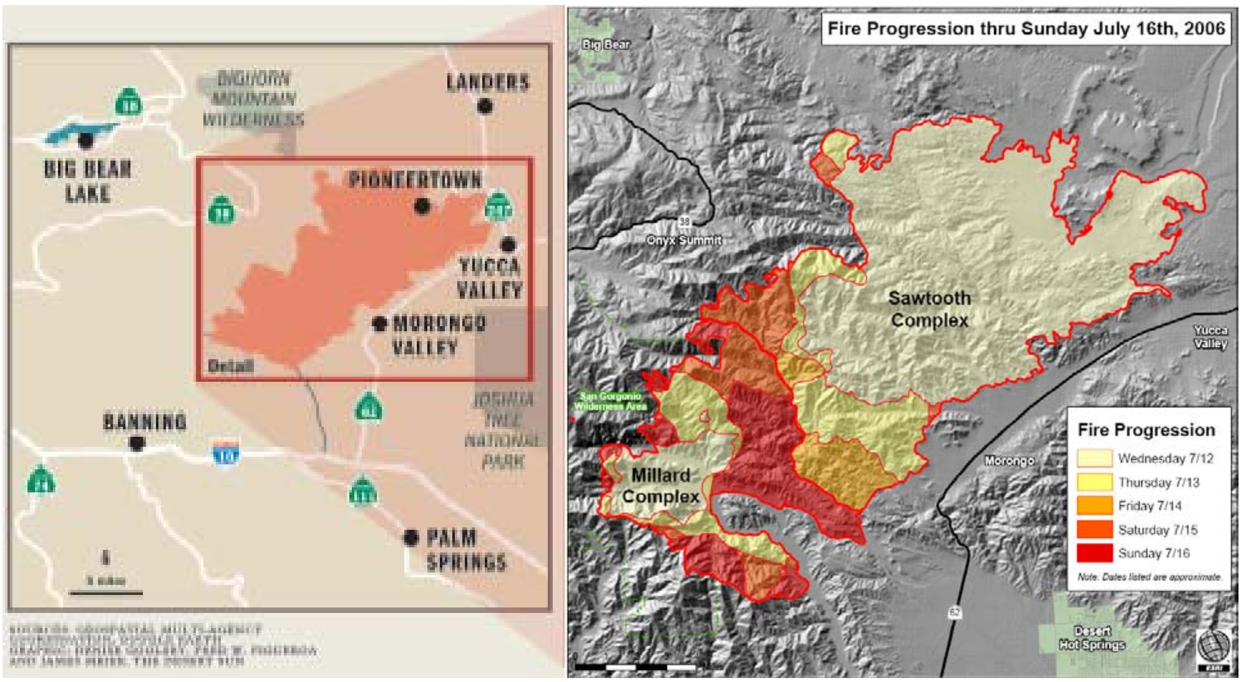


Figure 1
Map of Wildfire Progression through Sunday, July 16, 2006

(Maps Courtesy of The Desert Sun and ESRI)

Figure 2 shows visible satellite images at 1640 PST in the afternoon of July 15 and at 0645 PST in the morning of July 16. The arrows point to the smoke plume that was moving northward from the burn area. Significant convective clouds can be seen over much of Arizona and northern Mexico in the afternoon of July 15. The heat from the fires contributed to convection in the plume (pyrocumulus clouds) over the burn area and the plume rise is relatively deep in the atmosphere. This convective cloud can be seen protruding through the smoke in the photograph[5] shown in Figure 3, taken from the Coachella Valley in the morning of July 15 at 1019 PST. In the afternoon of July 15, the National Weather Service Office in San Diego predicted more thunderstorms to come in from Arizona overnight, with warnings of strong wind gusts and lightning expected

[5] Photo Source: The Desert Sun Newspaper, Palm Springs, CA

through the night and on July 16. Precipitation was predicted to remain as virga, mostly evaporating before reaching the ground. The second photograph in Figure 3 shows smoke in the evening sky looking northward from the Coachella Valley. The visible satellite image from the morning of July 16 (Figure 1) indicates that the convective activity decreased significantly by the daylight hours, with some clouds and possibly low level smoke remaining over the Coachella Valley, north of the Salton Sea, at this time.

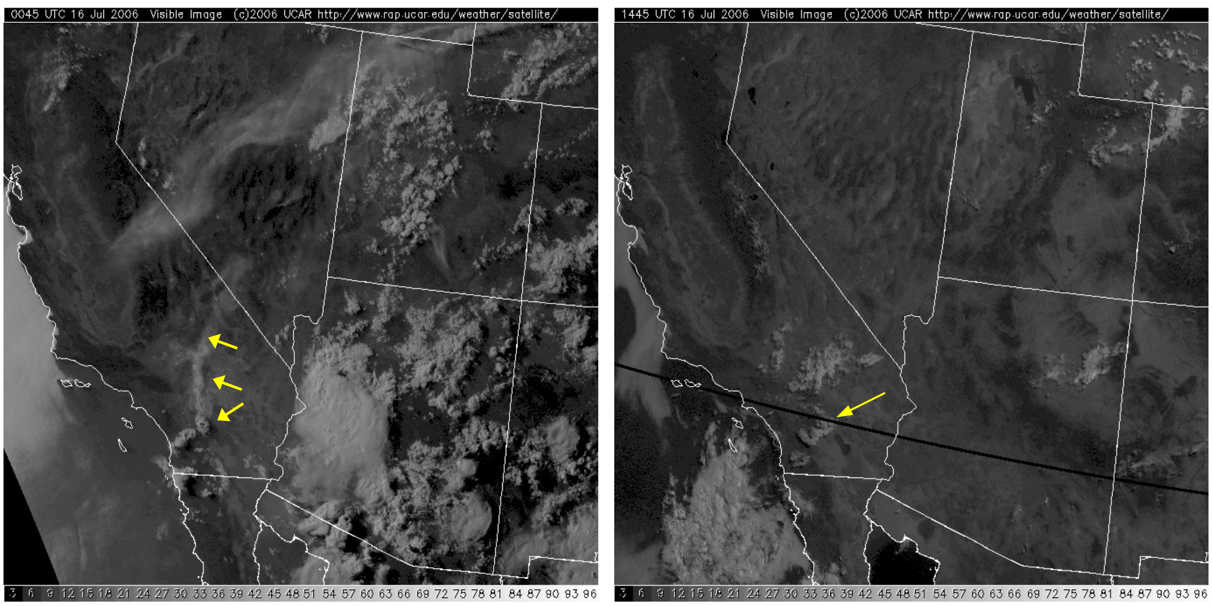


Figure 2
Visible Satellite Images at 1640 PST July 15 (0045 UTC, July 16) and 0645 PST (1445 UTC) on July 16
(The arrows in the first image indicate the smoke plume moving northward from the fire area on July 15 and settled in the Coachella Valley on July 16.)

FIGURE 3
Photos of the of Pyrocumulus Clouds above Smoke from the Sawtooth and Millard Fires at 1019 PST (left) and Smoke in the Sky at 1714 PST (right) on July 15, 2006, taken from the Coachella Valley
(Photographs Courtesy of The Desert Sun Newspaper)

The fire activity started to moderate during the day on July 16, as the southeasterly "monsoonal" flows started bringing higher humidity to the burn areas. Rapid gains were made in the containment of the Sawtooth Complex, however, the Whitewater Canyon area of the Millard Complex continued to be active through the day of July 16, until the fire behavior started to decrease in the evening.

The Sawtooth Complex was largely contained by July 18, with 61,700 acres burned at a cost estimated at $17,850,000. The Heart-Millard Complex fires were contained by July 24 at an estimated cost of over $14 Million with approximately 24,000 acres burned.

The AQMD daily air quality forecast predicted PM10/PM2.5 concentrations in the Unhealthy for Sensitive Groups range or higher, starting on Tuesday, July 12, for the Yucca Valley and Twentynine Palms areas of the Mojave Desert Air Basin. On July 13, a smoke advisory was issued related to these fires, with the area of elevated PM10/PM2.5 due to smoke impacts expanded to also include the East San Bernardino Mountains, Banning/San Gorgonio Pass and Coachella Valley areas. The smoke advisory was continued daily for these areas until July 18. The language of the smoke advisory that was issued during this period, along with predictions for Unhealthy for Sensitive Groups (Air Quality Index 101-150) or Unhealthy (AQI 151-200) PM10/PM2.5 concentrations in the five source-receptor areas given above, was as follows:

SPECIAL SMOKE ADVISORY: Valid Sunday, July 16, 2006

Due to the wildfires in the mountain areas of San Bernardino and Riverside Counties, areas of smoke have occurred. As a result, **concentrations of fine particulates are expected to reach the Unhealthy for Sensitive Groups level or higher in the smoke impacted areas**.

All individuals are urged to exercise caution and avoid unnecessary outdoor activities in the smoke impacted areas. People with respiratory or heart disease, the elderly and children should limit prolonged exertion.

While there are no wind measurements available from the Whitewater Canyon below the Sawtooth/Millard Complex fire area, it is highly likely that along with the increased fire activity in the canyon, the weak nighttime drainage flows also brought smoke and ash into the north-western end of the Coachella Valley. Drainage flows likely brought smoke from the Yucca Valley portion of the fire area as well. Wind data (shown in the next section) from the Whitewater Wash and Desert Hot Springs wind stations, as well as the Palm Springs Air Monitoring Station and Palm Springs Airport, indicated a few hours of weak drainage flow with a northerly component early in the morning. Some contribution from the fire activity is supported by the relatively high SSI PM2.5 and elevated SSI PM10 organic carbon and potassium analyses, shown in Table 3. The weak winds throughout the morning also allowed transported dust from the previous afternoon's thunderstorm activity over Arizona to be deposited over the Coachella Valley. The unimpressive potassium analysis from the Palm Springs SSI PM10 filter, indicates that the transported dust likely played a larger role in this PM10 exceedance than did the fire activity, given the short duration of the nighttime and early morning drainage flows that could have brought smoke into the Coachella Valley. While it appears from the PM10 speciation results that windblown dust had the greatest impact on the SSI PM10 exceedances on July 16, the wildfire smoke and ash likely contributed as well.

WINDBLOWN DUST ANALYSIS

The National Climatic Data Center's (NCDC) Event Record[6] documents eleven severe thunderstorm-related events in the Arizona deserts in the afternoon of July 15 and again in the afternoon of July 16. These are listed in Table 4. The wind data from the AQMD Coachella Valley air monitoring stations and the supplemental Coachella Valley Wind Network are shown in Tables 5 and 6, respectively. Tables 7 and 8 show the National Weather Service (NWS)/Federal Aviation Administration (FAA) weather observations. Figure 4 illustrates the wind data with a time series of the hourly wind vectors at each of these stations in and near the Coachella Valley, along with a plot of the hourly BAM PM10 data from Palm Springs on July 16.

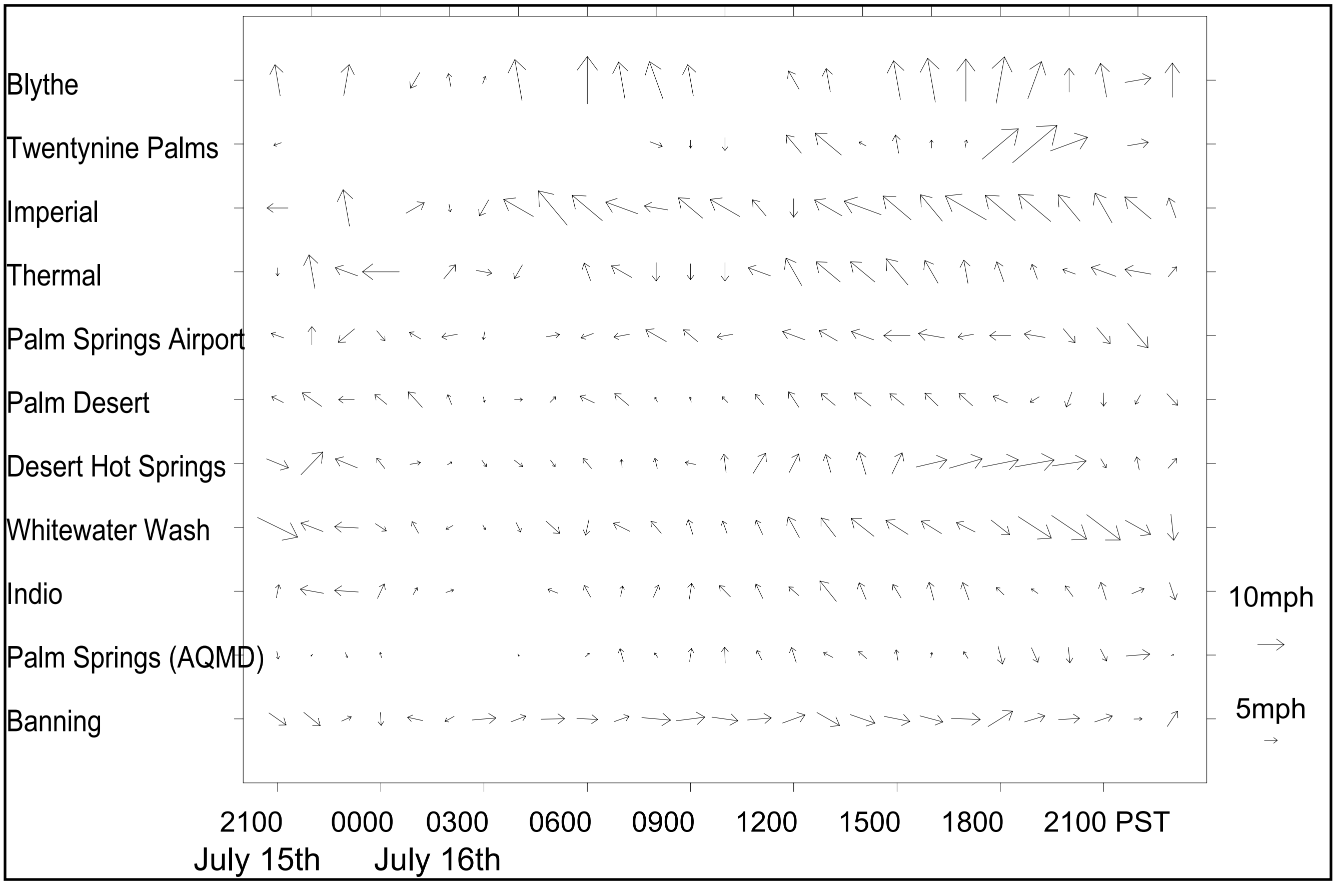
[6] National Climatic Data Center's Event Record: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

TABLE 4

Listing of Thunderstorm-Related Reports from the National Climatic Data Center Event Record from the Arizona Deserts on July 15 and 16, 2006

Location	Date/Time	Event Description
Dewey, AZ (Yavapai County, between Prescott & Flagstaff)	July 15 1440 PST	**Hail**, 3/4 inch diameter
Central AZ Deserts and Greater Phoenix Area	July 15 1530 – 1755 PST	**Dust Storm** Strong & gusty winds, estimated at 45 to 50 mph caused near zero visibility in a number of locations around the metro Phoenix area. Some power outages were reported, mainly in the West Valley area near Buckeye. Damage Estimate: $20,000
Tempe, AZ (Maricopa County, near Phoenix)	July 15, 1530 PST	**Thunderstorm Wind, Magnitude 69 mph** Trees uprooted near downtown Tempe.
Yarnell, AZ (Yavapai County, NE of Phoenix)	July 15, 1610 PST	**Thunderstorm Wind, Magnitude 67 mph** RAWS station 5 miles south of Yarnell recorded a 67 mph wind gust from a thunderstorm.
Tacna, AZ (Yuma County, east of City of Yuma)	July 15, 1915 PST	**Thunderstorm Wind, Magnitude 69 mph** Power poles down and sheds blown over 2 miles northwest of Tacna.
Dolan Springs, AZ (Mojave County, north of Kingman)	July 16 1650 – 1700 PST	**Thunderstorm Wind, Magnitude 66 mph**
Chloride, AZ (Mojave County, north of Kingman)	July 16 1700 – 1715 PST	**Thunderstorm Wind, Magnitude 72 mph** Small shed ripped up and wooden awning destroyed.
Cordes Junction, AZ (Yavapai County, near Prescott)	July 16, 1710 PST	**Thunderstorm Wind, Magnitude 63 mph** Thunderstorm wind gusts caused carport roof damage in Cordes Junction.
Bumble Bee, AZ (Yavapai County, near Prescott)	July 16, 1720 PST	**Tornado (F0, 10 yards wide)** A tornado crossed I-17 about one mile north of Sunset Point Rest Area. This area is mostly grassland and there were no reports of damage.
Picacho AZ (Southeast Pinal County, between Phoenix and Tucson)	July 16, 1900 – 1930 PST	**Dust Storm** A trained spotter traveling along Interstate 10 near the Town of Picacho reported that visibility was about 200 yards due to blowing dust.
Arizona City, AZ (Central Deserts, between Phoenix	July 16, 1930 PST	**Dust Storm**

and Tucson)		Very low visibility with blowing dust in Arizona City.



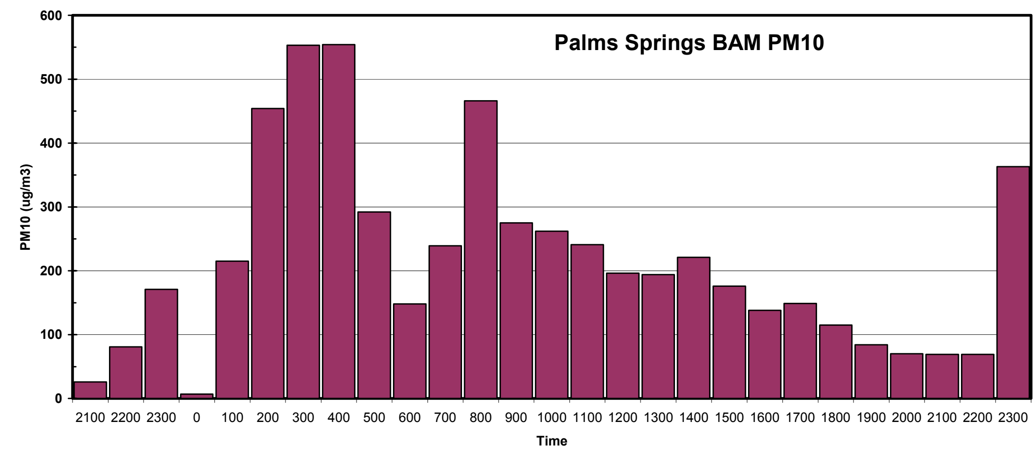


FIGURE 4

Time Series of Hourly Wind Vectors for Meteorological Stations in and near the Coachella Valley, along with the Hourly BAM PM10 (µg/m^3) from Palm Springs, on July 16, 2006

(Blank wind observations indicate calm winds, except for Twentynine Palms that does not report until 0600 PST.)

While the smoke from wildfires likely played a role in the PM10 concentrations measured in the Coachella Valley, the overall weak southeasterly flow over the southwestern U.S. along with intense thunderstorm activity during the previous afternoon and night over Arizona, suggests that windblown dust from thunderstorm outflows dominated the PM10 measurements. Large convective complexes developed over southwestern Arizona and northern Mexico, at the north end of the Gulf of California, in the afternoon of July 15. These are shown in the sequence of hourly infrared satellite images in Appendix A. The strong convection lasted through the night of July 15, after which it diminished and the cloud mass drifted westward aloft over southern California. This carried deeply entrained dust from the thunderstorm outflows that fell out over the Coachella and Imperial Valleys. Several past natural event analyses have shown similar transport of entrained dust generated by thunderstorm outflows over the Arizona and Mexican deserts that caused PM10 exceedances in the Coachella Valley.

The NCDC Event Record documents five severe thunderstorm-related events in the Arizona deserts in the afternoon of July 15, as listed in Table 4. High winds and windblown dust storms were reported, especially in the southern half of Arizona around Phoenix and near Yuma, between 1440 and 1915 PST. The satellite imagery clearly shows large mesoscale convective complexes that formed over southwestern Arizona and the Arizona/Mexico border during this time period. At 1440 PST on July 15, ¾ inch diameter hail was reported at Dewey, Arizona in Yavapai County, between Prescott and Flagstaff. A large dust storm was reported, between 1530 and 1755 PST, in the central Arizona deserts and the greater Phoenix area, with wind gusts estimated near 50 mph and very low visibilities. In nearby Tempe, thunderstorm winds reaching 69 mph uprooted trees around 1530 PST. Northeast of Phoenix a Remote Automated Weather Station (RAWS) near Yarnell recorded a 67 mph wind gust from a thunderstorm at 1610 PST. Later in the evening, at 1915 PST, Tacna, Arizona (east of the City of Yuma) had thunderstorm winds to 69 mph that downed power poles and toppled sheds. The cloud mass drifted slowly toward the west through the end of the day, bringing the entrained dust into southeastern California that was deposited throughout the morning of July 16 over the southern deserts and the Coachella Valley as the thunderstorm activity diminished.

The westward progression of the thunderstorm activity is evident from the timing of the NCDC Event Record reports and in the satellite imagery sequence. This westward progression of thunderstorm-generated windblown dust can be tracked into California to coincide the BAM PM10 peaks measured through the early morning hours at the Imperial County stations, as well as into the Coachella Valley. Evidence of a gust front passage, and accompanying thunderstorm activity, can be seen at Imperial Airport with wind gusts to 40 mph that occurred at 2200 PST on July 15 and to 25 mph at 0000 PST July 16. Blythe Airport also recorded a wind shift and gusts to 32 mph at 2200 on July 15. This passage occurred later at Thermal Airport with gusts to 21 mph at 0100 PST followed by reported low visibility (3-4 miles) and haze until 0700 PST. An hour after the gusts reached Thermal, at 0200 PST, the reduced visibilities and lingering haze were observed at Palm Springs Airport, although the high wind gusts no longer accompanied the transported dust at the Coachella Valley stations. The visibilities remained between 4 and 6 miles at Palm Springs Airport with haze reported until 1100 PST, as the entrained dust impacted the Coachella Valley under light wind conditions.

The winds at the Coachella Valley were relatively calm or light and variable through most of the early morning hours of July 16. The Palm Springs hourly BAM PM10 concentration was already over 200 $\mu g/m^3$ at 0100 PST on July 16, due to the transported dust and possibly wildfire smoke. This increased to peaks over 500 $\mu g/m^3$ at 0300 and 0400 PST. The hourly PM10 peaks occurred earlier at the Imperial County Niland and Westmoreland air monitoring stations and the concentrations above 150 $\mu g/m^3$ ended in Imperial County by 0600 PST (Table 2). This timing is consistent with transport of dust across Imperial County from the east and southeast. At 0600 PST the Palm Springs PM10 had also dropped to 148 $\mu g/m^3$. After this, the Palm Springs PM10 climbed to a secondary peak of 466 $\mu g/m^3$ at 0800 PST. This was apparently associated with a second gust front that moved eastward through Blythe at 0500 PST, with average wind speeds of 25 mph and gusts to 31 mph, followed by three hours of reported low visibilities (4-6 miles) and haze. Entrained dust was brought into the Coachella Valley by the weak southeasterly flow that had returned to the entire area by this time. This gust front did not move up through Imperial County like the earlier one and the BAM PM10 concentrations at Niland and Westmoreland did not increase. The Palm Springs BAM PM10 decreased gradually through the day, staying over 150 $\mu g/m^3$ until after the 1500 PST hour, due to the lingering dust cloud that was possibly enhanced by recirculation and convective mixing during the day in the Coachella Valley.

Recirculated smoke and ash from the ongoing wildfires to the north could also have been a factor in the lingering PM10 concentrations seen at Palms Springs and probably Indio. Reduced visibilities and smoke were observed at Twentynine Palms from the first reading of the day at 0600 PST through 1300, under generally calm or light and variable wind conditions. The Banning Airport air monitoring station winds were primarily light and onshore from the west throughout the day, bringing flow into the Coachella Valley, except for an hour of northerly winds at 0000 PST and light easterly flow from 0100 through 0200 PST. These observations support the possibility of terrain-induced nighttime/early morning drainage flows contributing smoke and ash into the Coachella Valley and explain the relatively low PM10 concentrations measured at Banning Airport. The weak northwesterly flows at the Whitewater Wash and Desert Hot Springs stations between 0300 and 0600 PST also lend support to the possibility that surface drainage flows occurred in the mountains at the north end of the Coachella Valley to bring in smoke and ash.

Convective activity increased again in the afternoon of July 16, mainly over Arizona and northern Mexico. This can be seen in the surface analyses and satellite imagery in Appendix A, starting at 1200 PST. Winds were erratic and gusty near the thunderstorms. The NCDC Event Record documents six thunderstorm-related events in Arizona during the afternoon of July 16, as shown in Table 4. Thunderstorm winds were reported in Mohave County, Arizona (northwestern Arizona, near Kingman) in the afternoon of July 16: at Dolan Springs reaching a magnitude of 66 mph at 1650 PST and lasting approximately 10 minutes; and at Chloride reaching 72 mph, with a small shed and a wooden awning destroyed, at 1700 PST and lasting 15 minutes. By this time, the satellite imagery shows well-developed convective complexes over much of Arizona and northern Mexico. In Yavapai County, Arizona (north of Phoenix, near Prescott), thunderstorm winds reached 63 mph at Cordes Junction at 1710 PST with some damage and a small tornado was reported near Bumble Bee at 1720 PST. Dust storms with blowing dust and low visibilities were reported in the Central Deserts region between Phoenix and Tucson near Picacho (Pinal County) at 1900 PST and near Arizona City at 1930 PST. These were associated with a rapidly developing convective complex over this area, as seen in the satellite images. As was seen into the evening of July 15, the thunderstorms drifted westward through the end of the day on July 16, leaving significant cloud cover over southern California that dissipated later in the morning of July 17.

The high PM10 seen in the Palms Springs BAM data during the last hour of the day of July 16, and for a few hours early the next morning, was related to the thunderstorm outflow winds. Gusty northwesterly winds were recorded at the AQMD Whitewater Wash and Desert Hot Springs wind stations during the hours from 1800 through 2100 PST, with peak gusts of 29 mph. The boundary of thunderstorms cells moved westward into the California deserts, through the Coachella Valley area to the coast near San Diego by the end of the day. The Blythe Airport (Table 8) reported lightning to the east at 2000 PST with southerly winds, a wind shift at 2123 PST, then more lightning, gusty winds and a thunderstorm starting before midnight (0000 PST) July 17 and continuing for two hours. Twentynine Palms MCAS observed lightning and cumulonimbus clouds starting at 2000 PST on July 16, continuing through the end of the evening, along with a 22 mph wind gust at 2100 PST. Thermal Airport (Table 7) reported lightning starting at 2100 PST, with thunderstorms starting the next hour and continuing through 0000 PST on July 17. At Palm Springs Airport, the winds shifted from the northwest to southerly at 2300 PST, increasing to 23 mph with gusts to 33 mph and visibilities down to 1 mile followed by a brief period of heavy rain. The AQMD Whitewater Wash wind station (Table 6) recorded gusts to 27 mph during the 2300 PST hour. The BAM hourly PM10 measurement for 2300 PST was 363 $\mu g/m^3$ at this time.

CONCLUSION

While the analysis of this event is somewhat complex, with erratic winds, dust transport from thunderstorm outflows and nearby wildfires, there can be little doubt that this episode qualifies as a natural event under the U.S. EPA Exceptional and Natural Events Policies. Windblown dust transported from thunderstorm activity over Arizona played a dominant role in the measured PM10 exceedances at Indio and Palms Springs, the timing of which has been shown with sequential satellite imagery, event record reports, meteorological observations, and the BAM hourly PM10 measurements at Palms Springs and two Imperial County stations. Smoke and ash from the Sawtooth/Millard wildfire complex likely contributed to the measured PM10 as well. Therefore, AQMD staff recommends the flagging of the PM10 NAAQS violations at the both the Palm Springs and Indio air monitoring stations on July 16 as natural events in the U.S. EPA Air Quality System and hereby requests the concurrence of the California Air Resources Board (ARB) and the U.S. EPA for the flags submitted by AQMD with the data for this period.

TABLE 5

Hourly Wind Directions (degrees), Wind Speeds (mph) and Maximum 1-Minute Average Speed for each Hour (mph) for AQMD Air Quality Monitoring Stations in the Coachella Valley and San Gorgonio Pass on July 16, 2006

		Banning Airport Monitoring Station			Palm Springs Monitoring Station			Indio Monitoring Station		
DATE	**HOUR (PST)**	**WD (deg)**	**WS (mph)**	**Maximum 1-Minute Avg. (mph)**	**WD (deg)**	**WS (mph)**	**Maximum 1-Minute Avg. (mph)**	**WD (deg)**	**WS (mph)**	**Maximum 1-Minute Avg. (mph)**
7/15/06	2100	305	8	14	349	3	7	191	5	9
	2200	309	8	11	044	1	6	100	9	13
	2300	245	4	8	337	2	6	94	9	11
7/16/06	0000	356	5	7	166	2	6	205	6	9
	0100	102	6	6	CLM	0	5	210	3	6
	0200	061	4	12	CLM	0	1	252	3	5
	0300	265	9	11	CLM	0	2	CLM	0	3
	0400	249	6	11	333	1	2	CLM	0	2
	0500	269	9	10	CLM	0	6	111	4	5
	0600	273	8	10	229	2	2	151	5	11
	0700	250	6	10	165	5	6	191	4	8
	0800	275	11	11	145	2	6	203	5	9
	0900	263	11	16	189	5	6	189	6	7
	1000	278	10	14	178	6	6	136	6	8
	1100	265	9	14	153	4	9	154	6	10
	1200	250	9	14	163	6	7	131	5	10
	1300	300	10	14	117	4	7	141	10	11
	1400	289	10	16	132	4	8	157	7	10
	1500	281	10	14	170	4	7	149	6	10
	1600	285	9	14	191	2	7	165	7	9
	1700	272	11	15	147	3	4	160	7	10
	1800	238	11	13	346	7	8	134	4	8
	1900	253	8	15	336	6	9	125	3	5
	2000	266	8	14	354	6	10	143	5	8
	2100	251	7	11	333	5	9	163	7	10
	2200	268	3	13	265	9	12	247	5	7
	2300	214	7	14	253	1	9	341	7	9
	0000	292	5	11	332	1	4	287	5	8

TABLE 6

Hourly Wind Directions (degrees) and Speeds with Peak Gusts (mph) for AQMD Supplemental Wind Monitoring Stations in the Coachella Valley on July 16, 2006

		Whitewater Wash Blowsand Site			Desert Hot Springs Wind Station			Palm Desert Wind Station		
DATE	**HOUR (PST)**	**WD (deg)**	**WS (mph)**	**Gust (mph)**	**WD (deg)**	**WS (mph)**	**Gust (mph)**	**WD (deg)**	**WS (mph)**	**Gust (mph)**
7/15/06	2100	296	17	**31**	292	9	22	117	5	20
	2200	111	9	17	224	12	23	125	9	21
	2300	93	9	18	112	9	20	89	6	15
7/16/06	0000	303	5	11	142	5	11	129	6	14
	0100	151	5	11	260	4	7	138	8	17
	0200	60	3	7	237	2	5	158	4	12
	0300	333	2	4	325	3	5	346	2	5
	0400	333	4	7	309	4	8	271	3	7
	0500	312	7	17	324	3	7	224	3	8
	0600	12	6	12	140	5	9	115	6	15
	0700	116	7	14	175	3	12	130	7	18
	0800	139	6	11	167	4	10	151	2	9
	0900	162	6	11	101	4	12	166	2	7
	1000	161	5	11	173	7	20	135	3	10
	1100	155	6	15	212	9	19	141	5	11
	1200	151	9	16	207	8	20	147	7	14
	1300	142	9	17	164	7	20	130	7	16
	1400	128	11	21	163	9	18	128	8	16
	1500	122	10	17	206	9	22	129	7	14
	1600	122	9	15	257	12	22	134	7	12
	1700	117	8	13	254	13	23	132	7	12
	1800	308	9	**27**	259	14	**29**	115	6	13
	1900	303	15	**25**	260	15	**28**	59	4	9
	2000	304	16	**29**	262	13	**29**	21	6	18
	2100	307	16	24	329	4	12	358	5	11
	2200	299	11	23	169	5	12	30	4	15
	2300	354	10	**27**	222	5	12	317	6	13
7/17/06	0000	300	6	13	174	4	7	269	4	10

TABLE 7

Hourly Wind Directions (degrees), Wind Speeds with Wind Gusts (mph, with gusts indicated by G when reported), and Visibilities (statute miles, when reported) for National Weather Service Stations on Sunday, July 16, 2006

(HZ = Haze, BLDU = Blowing Dust, BLSA = Blowing Sand, WSHFT = Wind Shift, LTG = Lightning, TS = Thunderstorm, RA = Rain, +RA = Heavy Rain, CB = Cumulonimbus Clouds)

		Palm Springs Airport			Thermal Airport			Imperial Airport		
DATE	**HOUR (PST)**	**WD (deg)**	**WS (mph)**	**VIS (miles)**	**WD (deg)**	**WS (mph)**	**VIS (miles)**	**WD (deg)**	**WS (mph)**	**VIS (miles)**
7/15/06	2100	110	5	10	VRB	3	10	090	8	10 LTG
	2200	180	7	10	170	13	10	130	16**G40**	**4 HZ** LTG
	2300	050	8	10	110	9	8	170	14	**4 HZ** LTG
7/16/06	0000	320	5	10	090	14	9	180	14**G25**	**6 HZ**
	0100	120	5	10	120	13G21	**4 HZ**	240	8	9 LTG, RA
	0200	080	6	**5 HZ**	220	7	**4 HZ**	350	3	10
	0300	010	3	**4 HZ**	280	6	**4 HZ**	030	7	9
	0400	CLM	0	**5 HZ**	030	6	**4 HZ**	120	13	10 WSHFT
	0500	260	5	**4 HZ**	CLM	0	**3 HZ**	140	17	10
	0600	070	5	**4 HZ**	160	7	**4 HZ**	130	15	9
	0700	080	6	**5 HZ**	120	9	10	110	13	10
	0800	120	9	**4 HZ**	VRB	7	10	100	9	10
	0900	130	7	**5 HZ**	VRB	6	10	130	12	10
	1000	080	6	**6 HZ**	VRB	7	10	120	13	10
	1100	CLM	0	7	110	9	10	140	8	10
	1200	110	9	9	150	12	10	VRB	7	10
	1300	120	8	8	130	12	10	120	12	10
	1400	110	9	8	130	12	10	110	15	10
	1500	090	10	9	140	13	10	130	14	10
	1600	100	10	9	150	10	10	140	13	10
	1700	080	6	10	170	9	10	120	18	10
	1800	090	8	9	160	8	10	130	15	10
	1900	100	8	9	160	6	10	130	16	10
	2000	320	7	10	110	5	10	140	13	10
	2100	320	8	10	110	10	10 LTG	150	13	10
	2200	320	12	10	100	10	10 LTG, TS	130	13	10
	2300	180	23**G33**	**1** +RA	220	5	10 LTG, TS	160	8	10
7/17/06	0000	CLM	0	**4** RA	220	3	10 TS	120	6	10

TABLE 8

Hourly Wind Directions (degrees), Wind Speeds with Wind Gusts (mph, with gusts indicated by G when reported), and Visibilities (statute miles, when reported) for National Weather Service Stations on Sunday, July 16, 2006

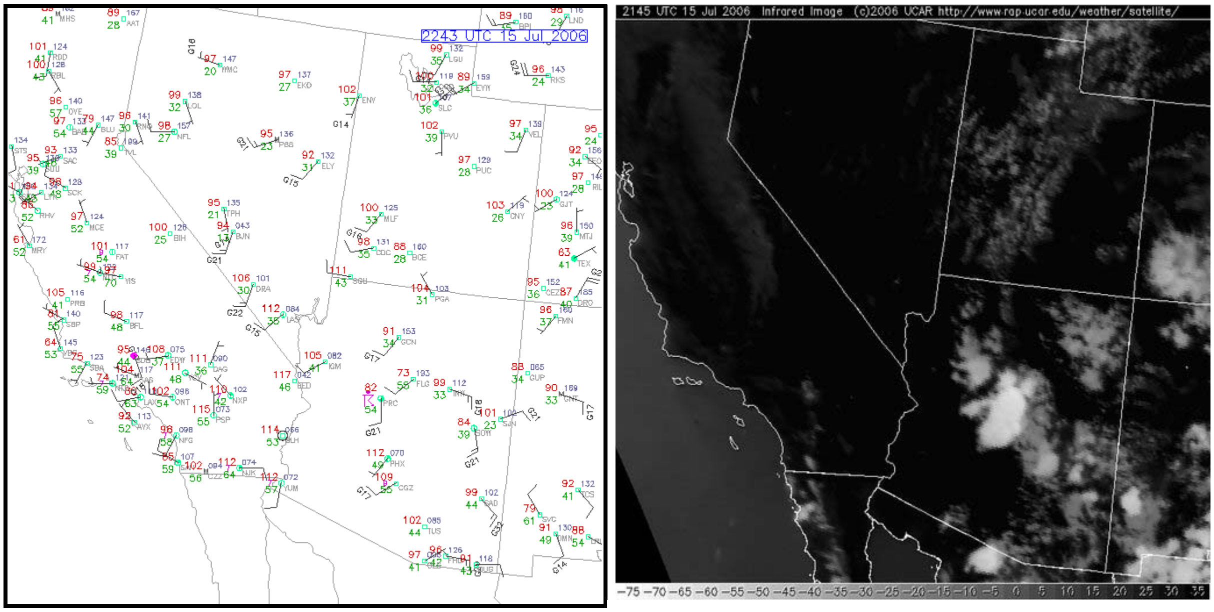
(HZ = Haze, BLDU = Blowing Dust, BLSA = Blowing Sand, WSHFT = Wind Shift, LTG = Lightning, TS = Thunderstorm, RA = Rain, +RA = Heavy Rain, CB = Cumulonimbus Clouds)

		Twentynine Palms MCAS			Blythe Airport					
DATE	HOUR (PST)	WD (deg)	WS (mph)	VIS (miles)	WD (deg)	WS (mph)	VIS (miles)			
7/15/06	2100	070	3	7	170	12	10			
	2200				170	20**G32**	10 WSHFT			
	2300				190	12	10			
7/16/06	0000				CLM	0	10 LTG			
	0100				030	7	10			
	0200				170	5	10			
	0300				200	3	10			
	0400				170	16	10			
	0500				180	**25G31**	9			
	0600	CLM	0	7	180	18	**4 HZ**			
	0700	CLM	0	**7 FU**	170	14	**4 HZ**			
	0800	290	5	**7 FU**	160	15	**6 HZ**			
	0900	VRB	3	**7 FU**	170	12	10			
	1000	VRB	5	**7 FU**						
	1100	CLM	0	**7 FU**						
	1200	140	9	**7 FU**	150	8	10			
	1300	130	13	**7 FU**	170	9	10			
	1400	120	3	7	180	10G18	10			
	1500	170	7	7	170	15	10			
	1600	180	3	7	170	17	10			
	1700	190	3	7	180	16	10			
	1800	230	18	7	190	18	10			
	1900	230	22	7	200	15	10			
	2000	250	15	7 LTG, CB	180	9	10 LTG			
	2100	230	16G22	7 LTG, CB	170	13	10			
	2200	260	8	7 CB	260	10	10 WSHFT			
	2300				180	13	10			
7/17/06	0000	220	16	7 CB	180	18	10 LTG, TS			

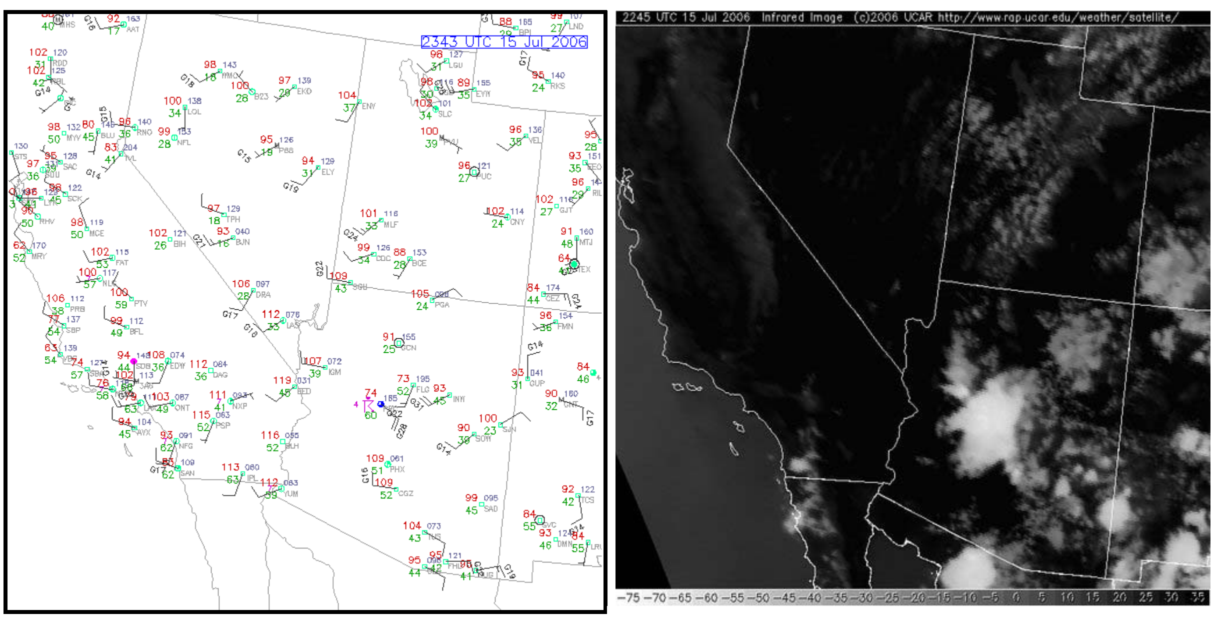
APPENDIX A

Hourly Plots of NWS/FAA Surface Weather Observations and Infrared Satellite Imagery from Approximately 1700 PST in the Afternoon of July 15, 2006 (0100 UTC, July 16) through 0600 PST (1400 UTC) in the Morning of July 17, 2006

Note: The Universal Coordinated Time (UCT) stamps on the surface observation plots are mislabeled by one hour, such that the 0143 UTC plot actually contains the 0043 UTC NWS METAR data, etc. The figure captions in Pacific Standard Time (PST) are correct.



1400 PST, July 15, 2006



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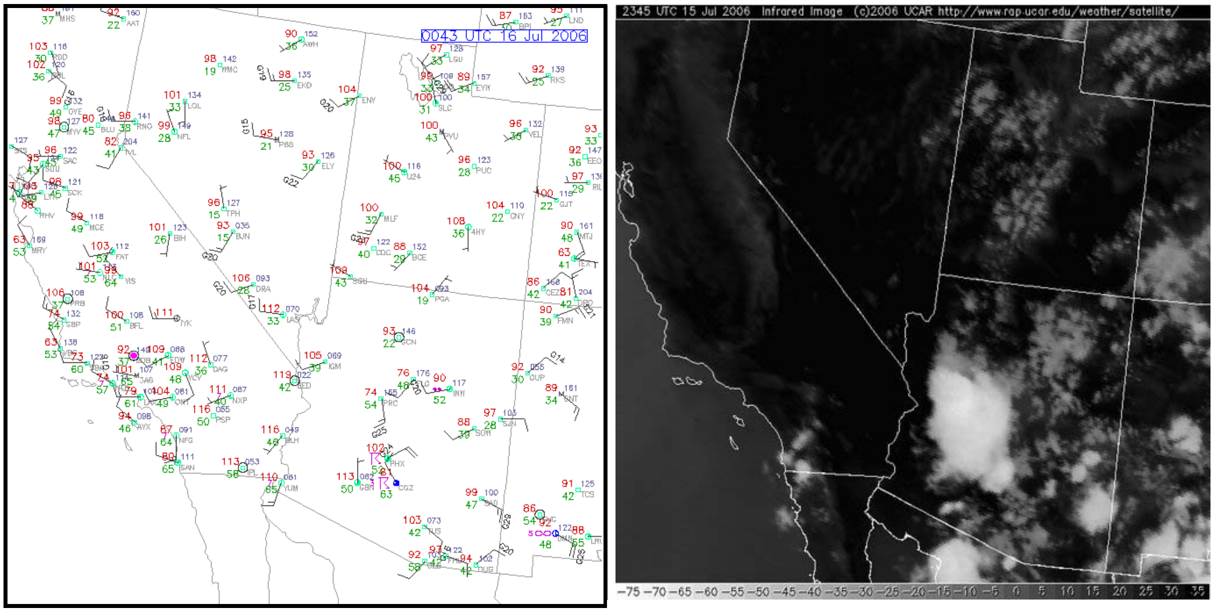

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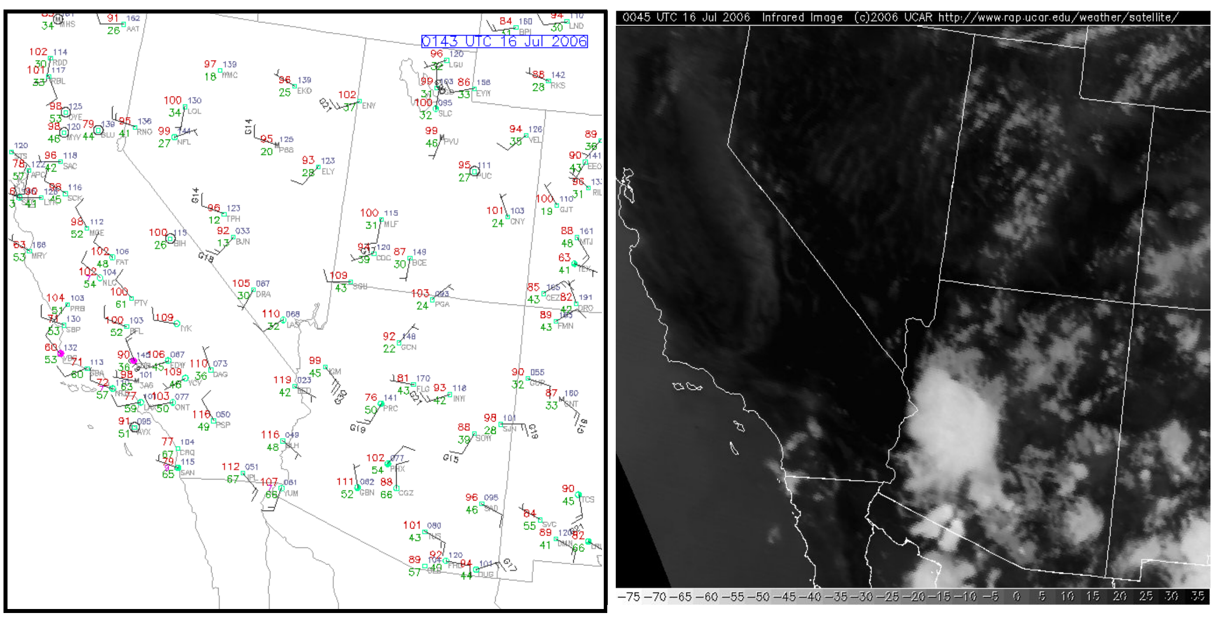
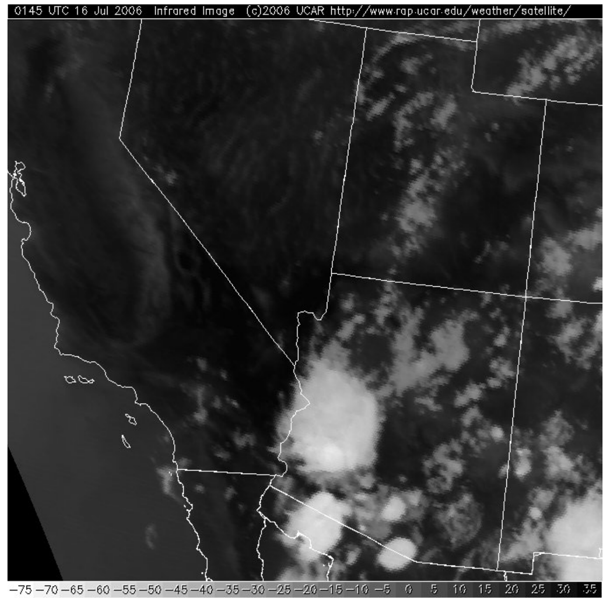
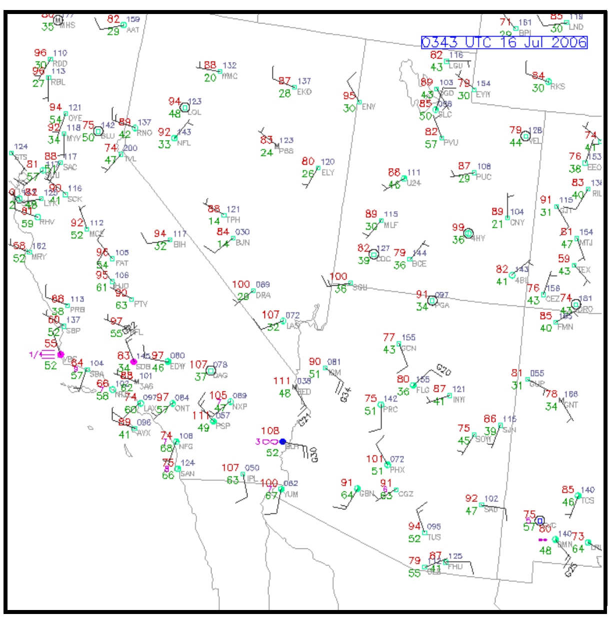
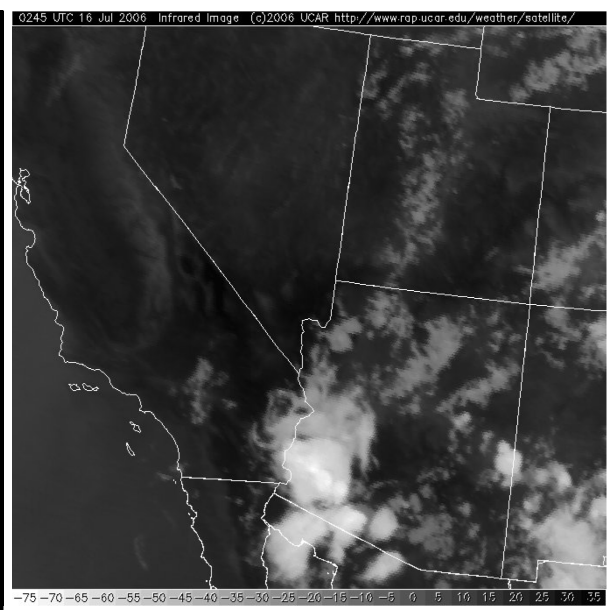


1700 PST, July 15, 2006

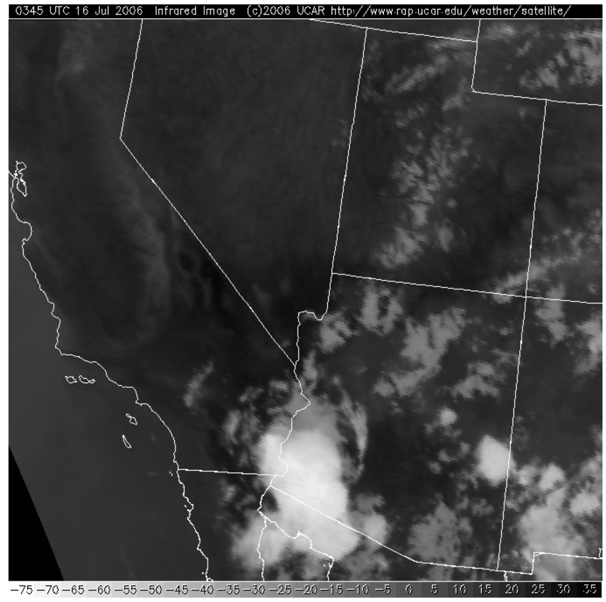


1800 PST, July 15, 2006

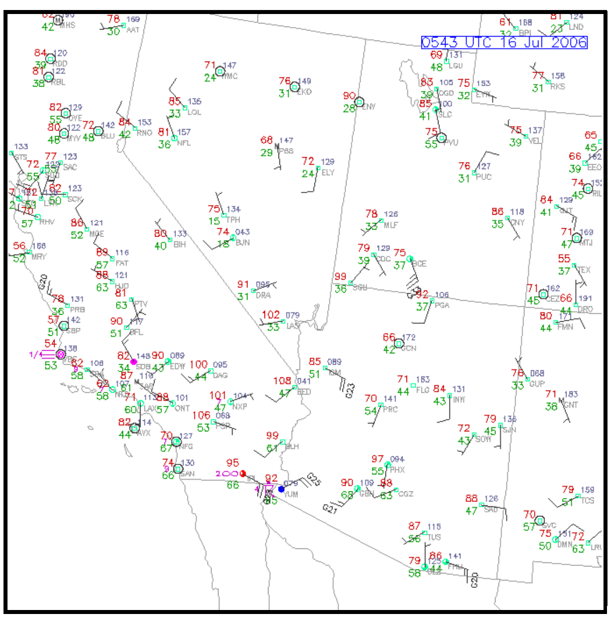


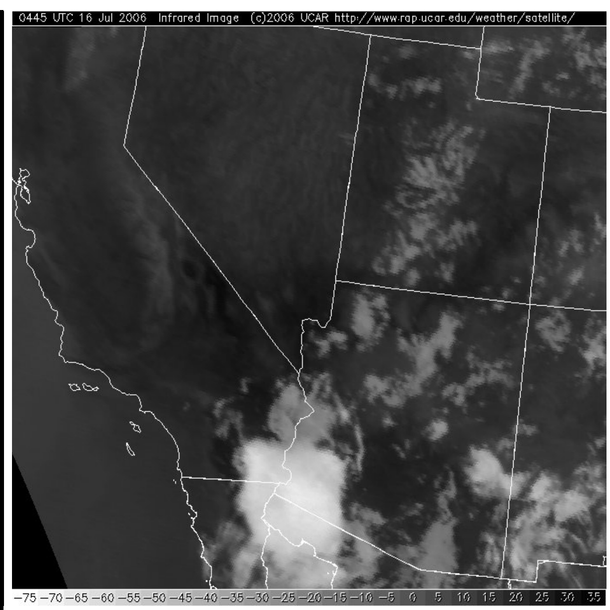


1900 PST, July 15, 2006

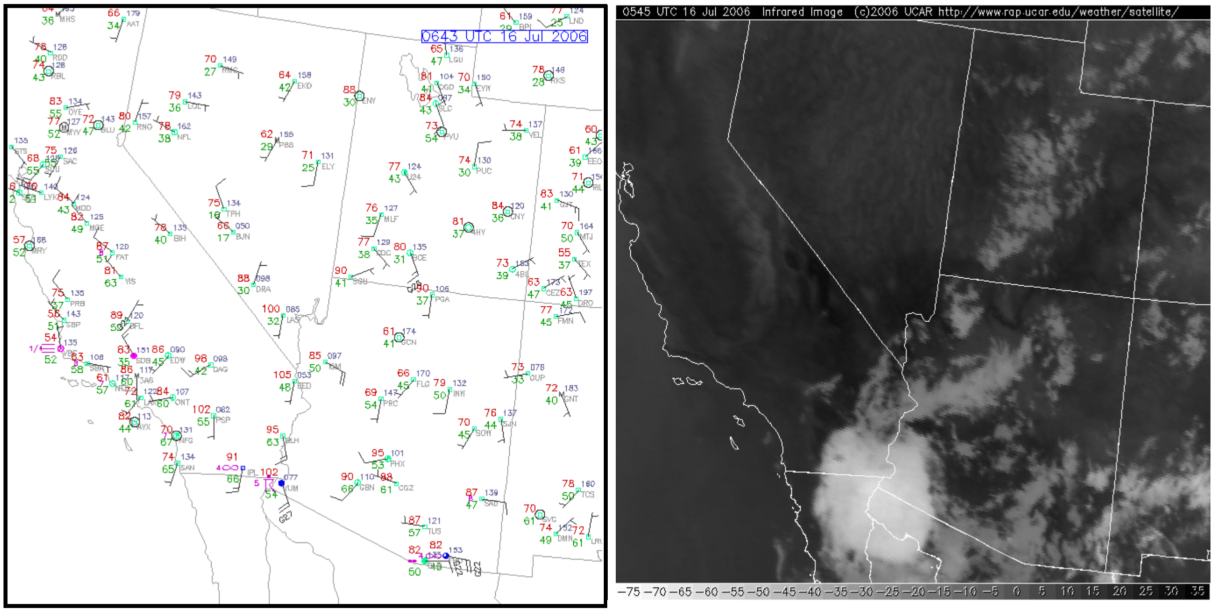


2000 PST, July 15, 2006

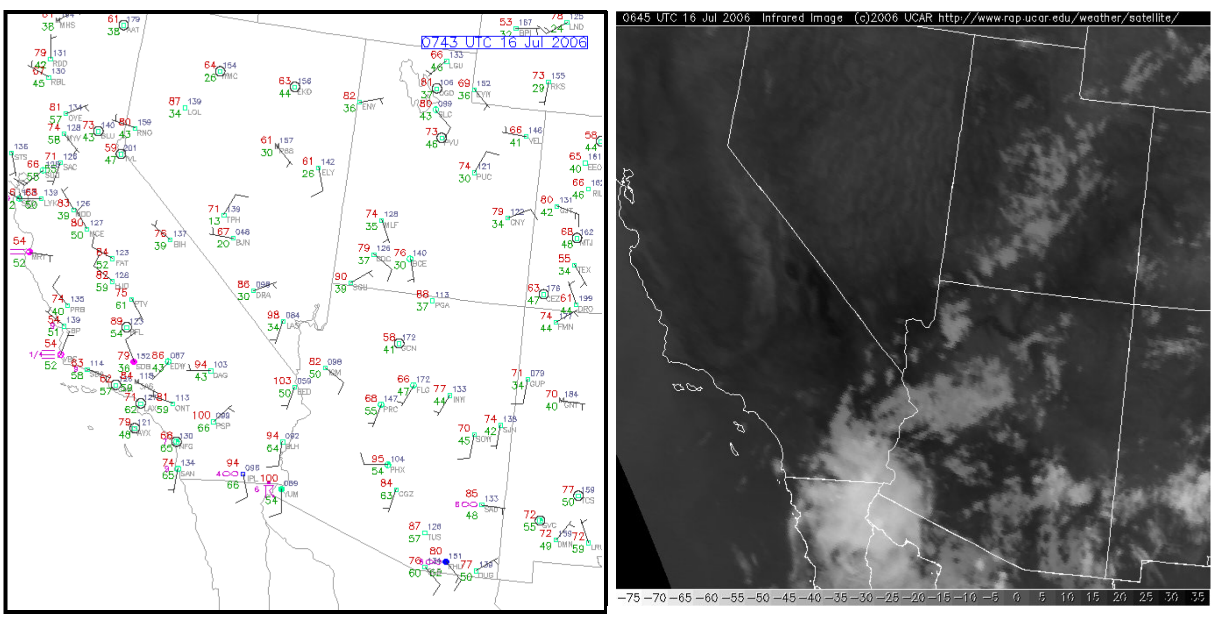




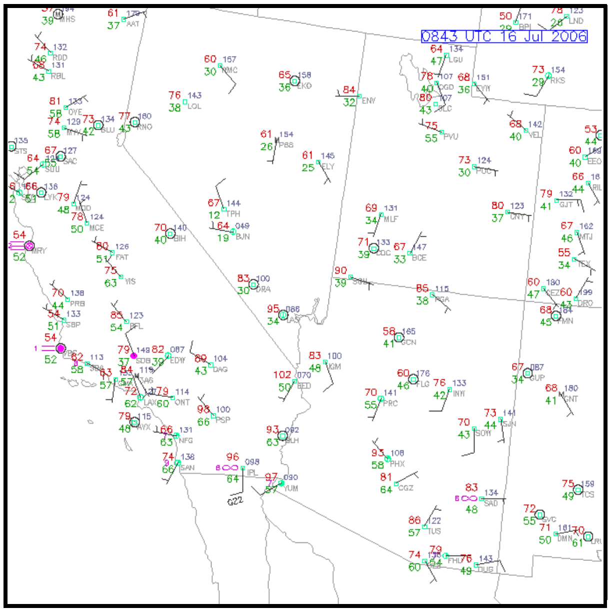
2100 PST, July 15, 2006

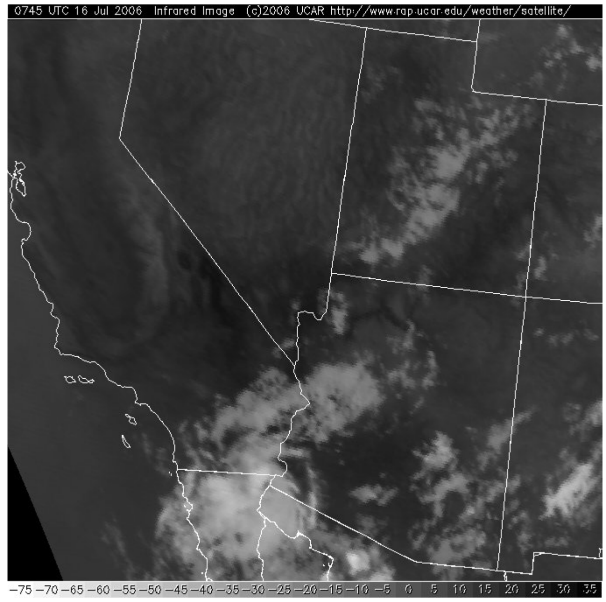


2200 PST, July 15, 2006

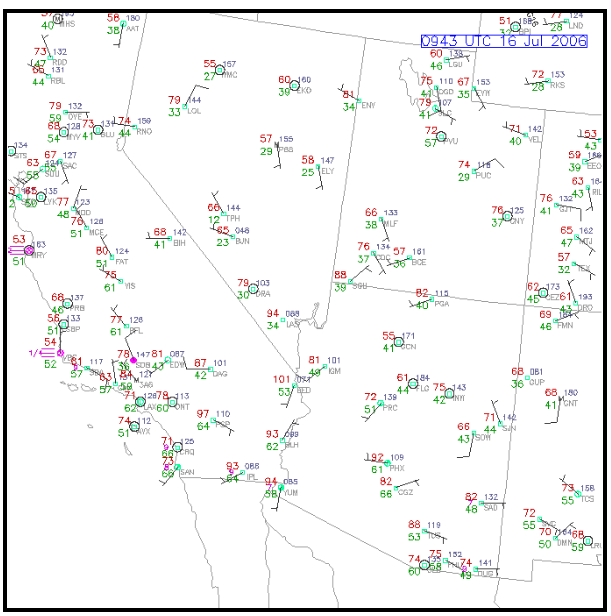


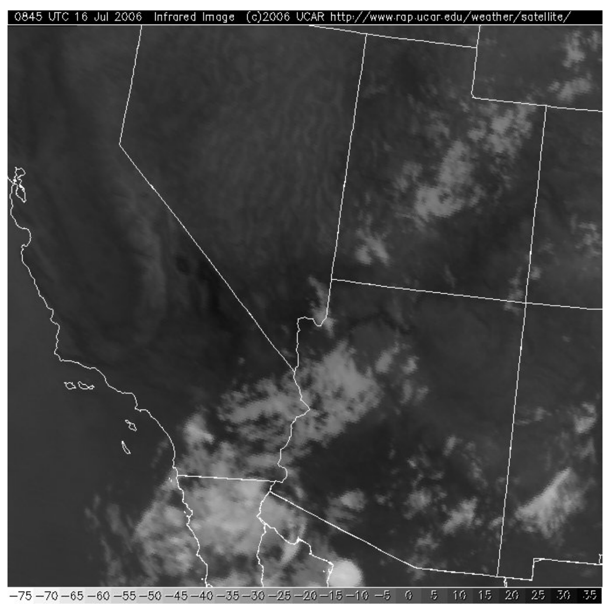
2300 PST, July 15, 2006





0000 PST, July 16, 2006





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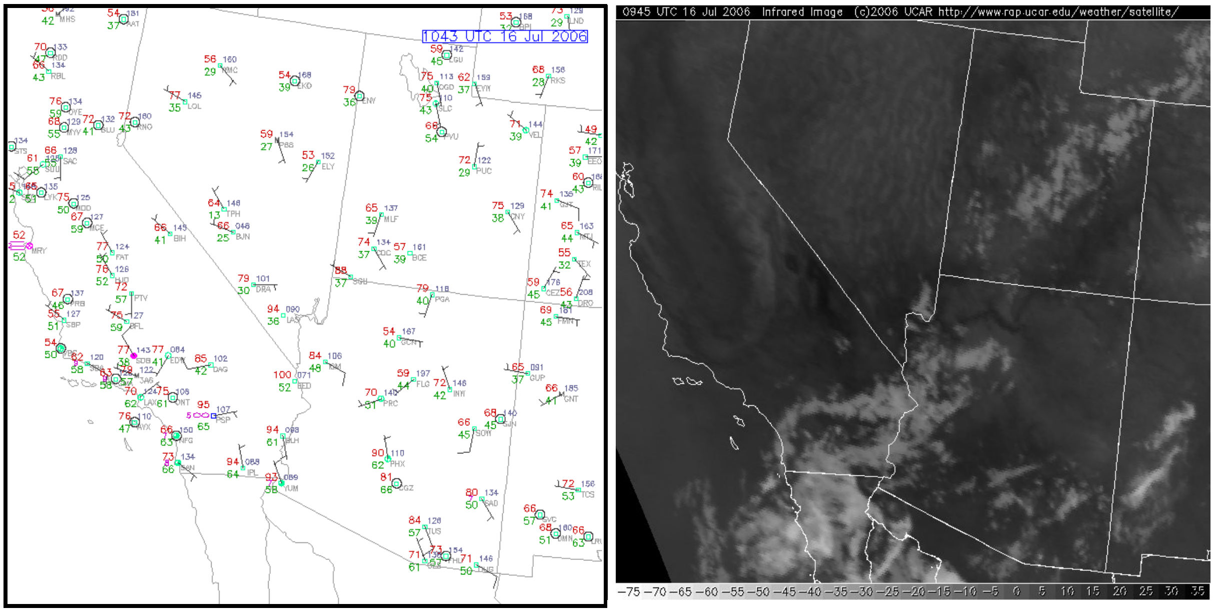
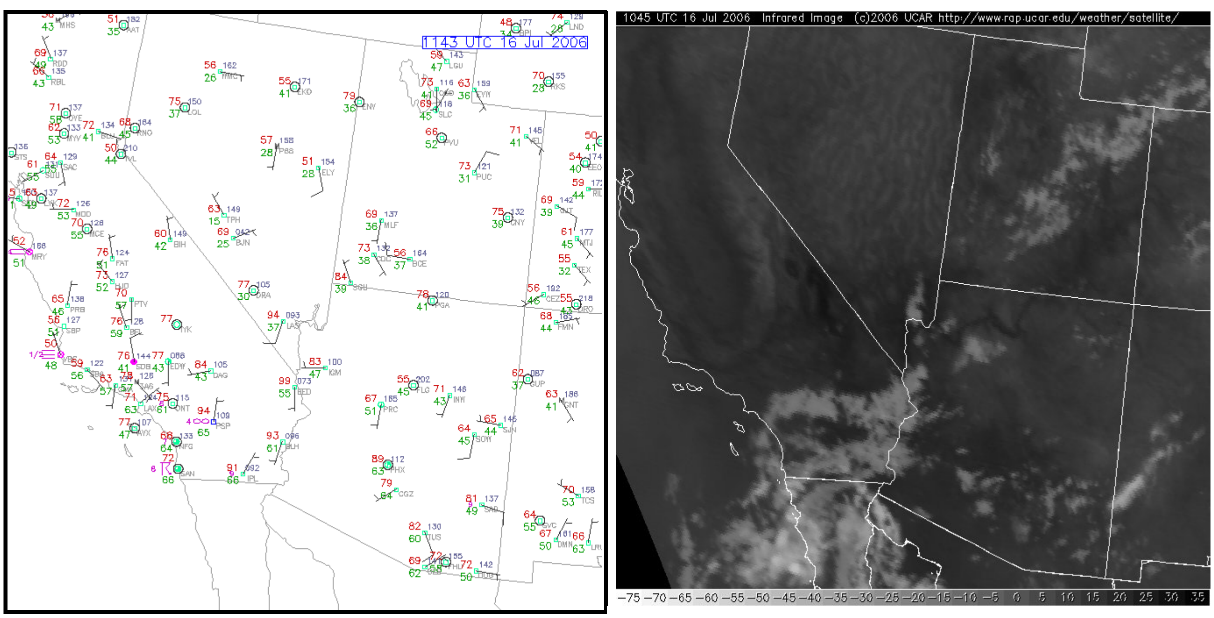
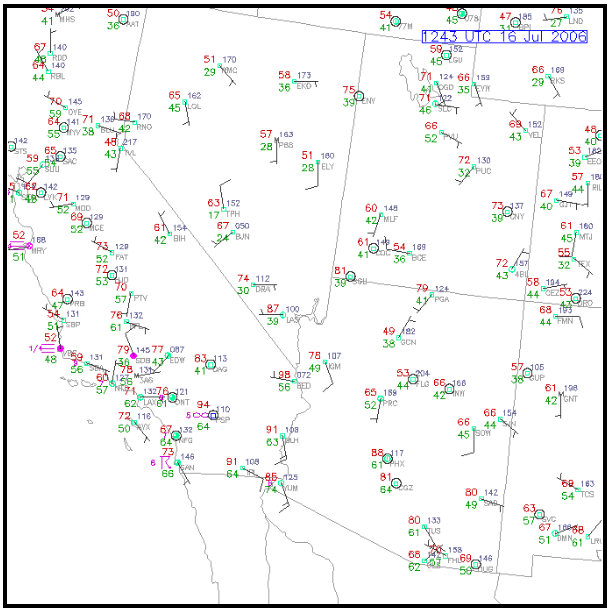


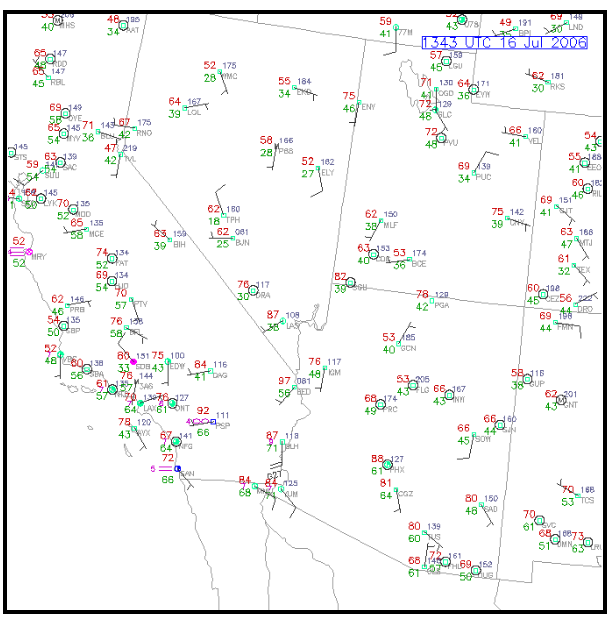
0200 PST, July 16, 2006



0300 PST, July 16, 2006



0400 PST, July 16, 2006



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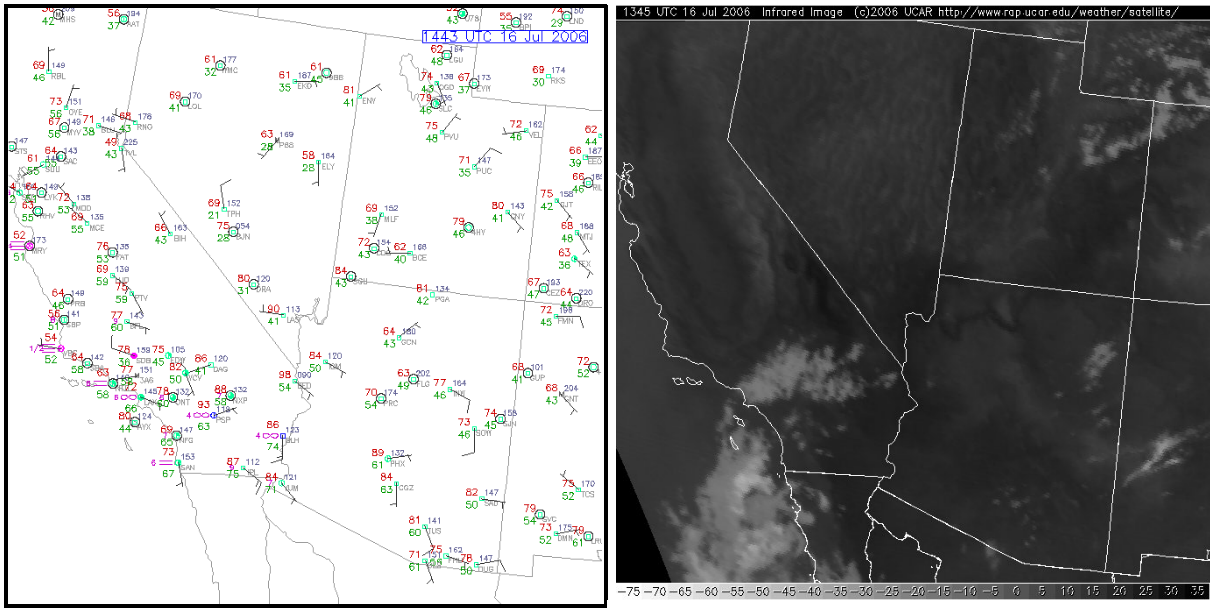
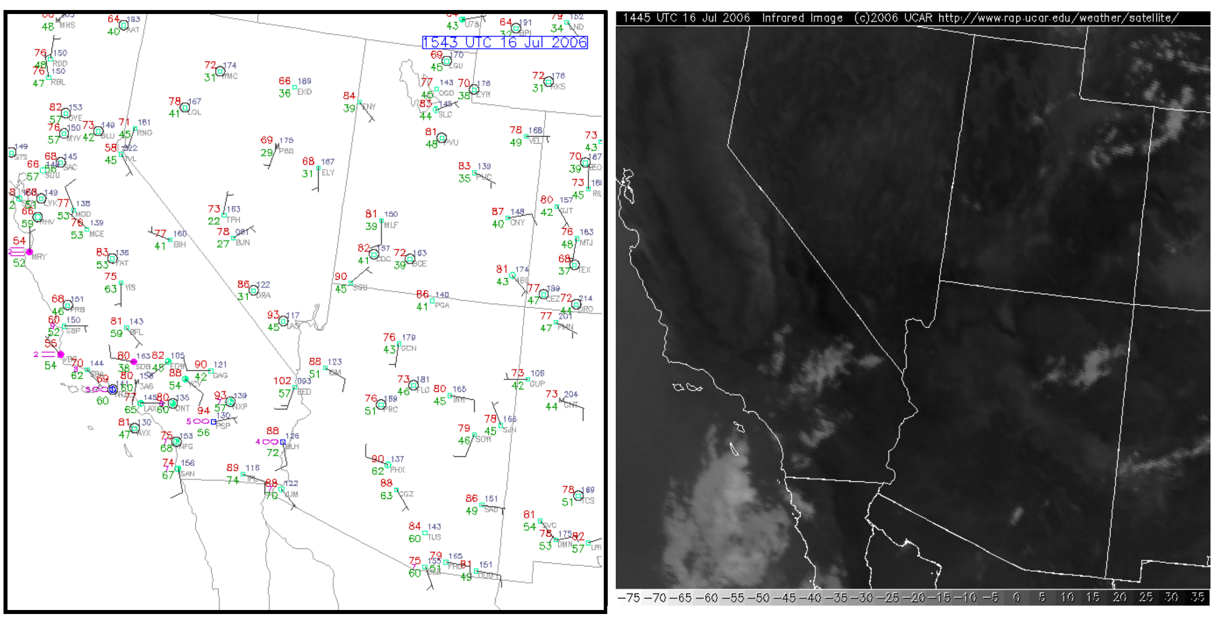
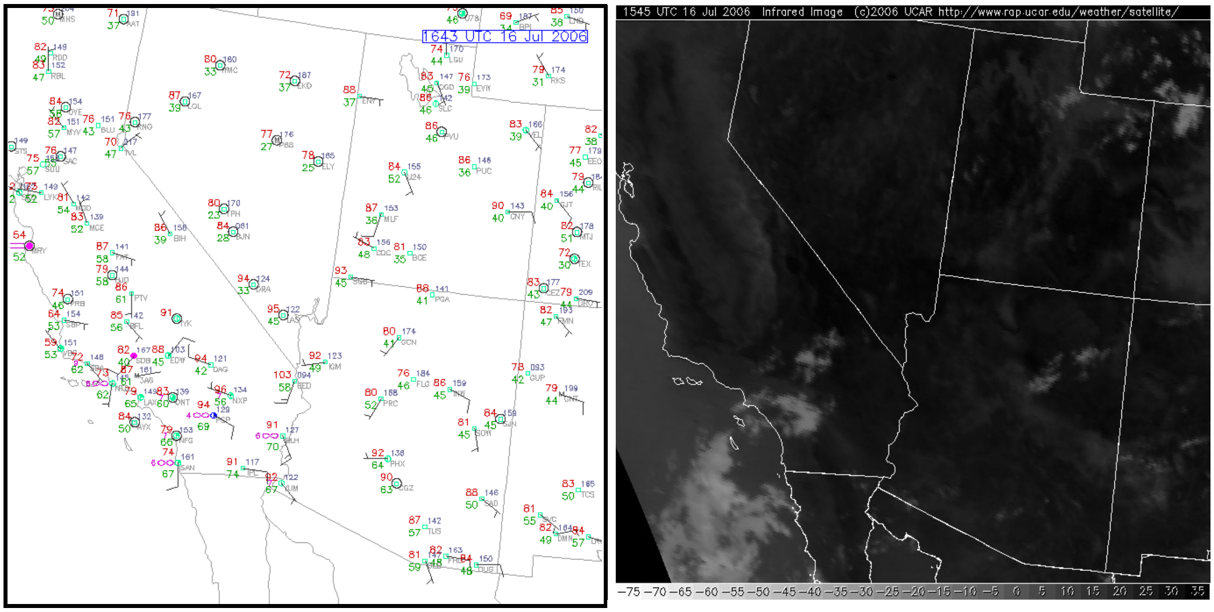


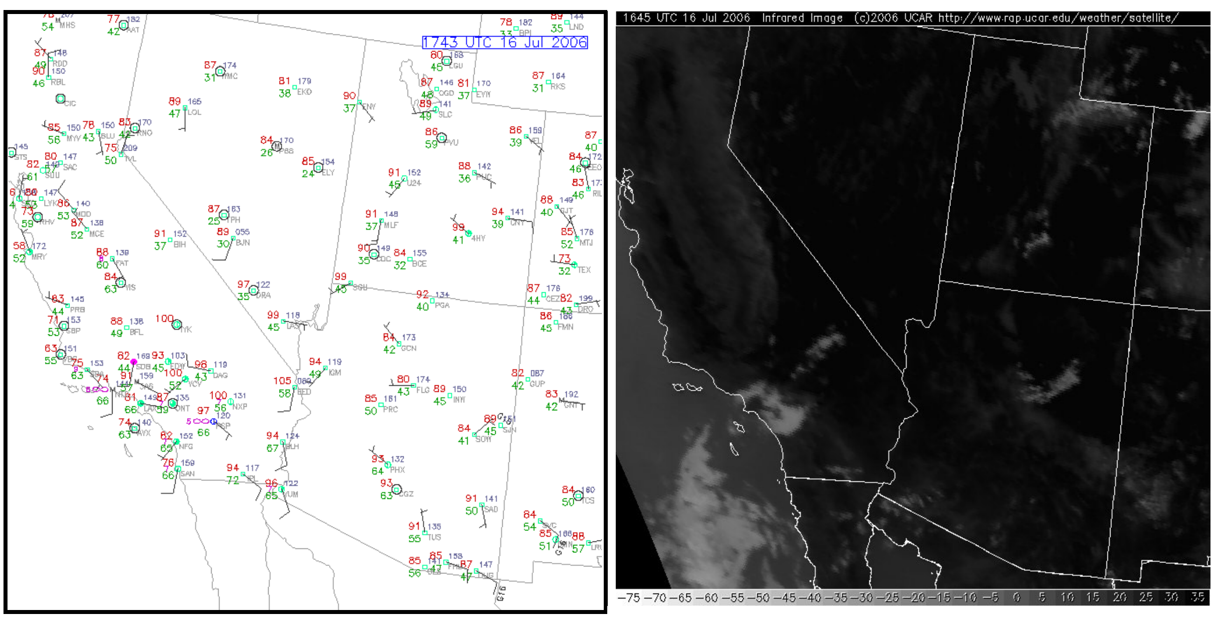
0600 PST, July 16, 2006



0700 PST, July 16, 2006



0800 PST, July 16, 2006



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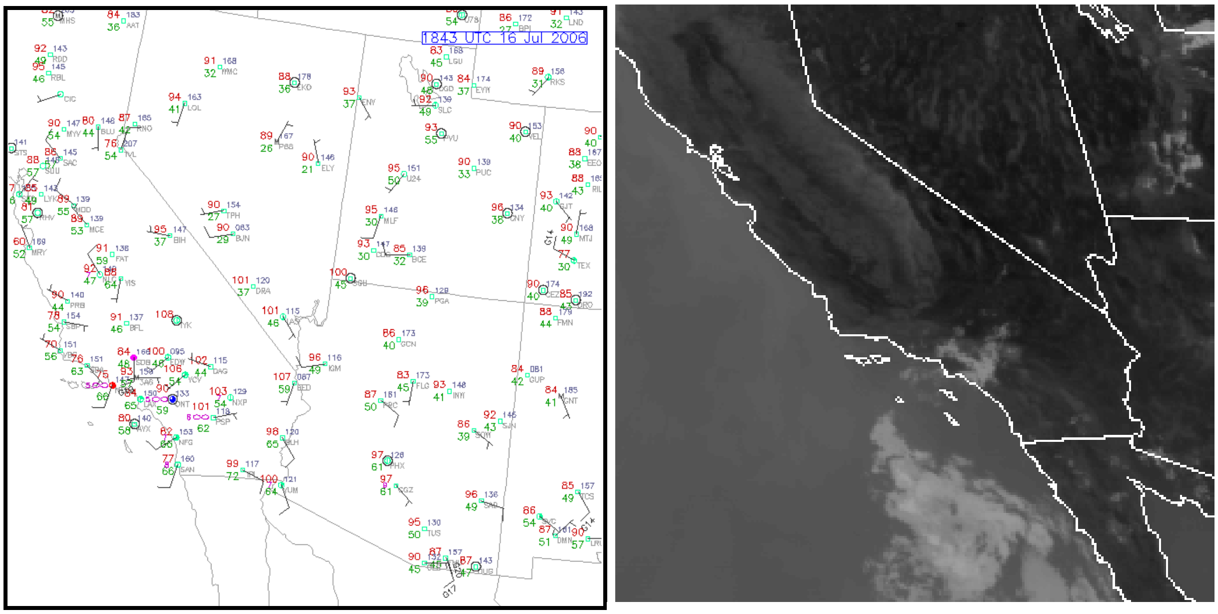

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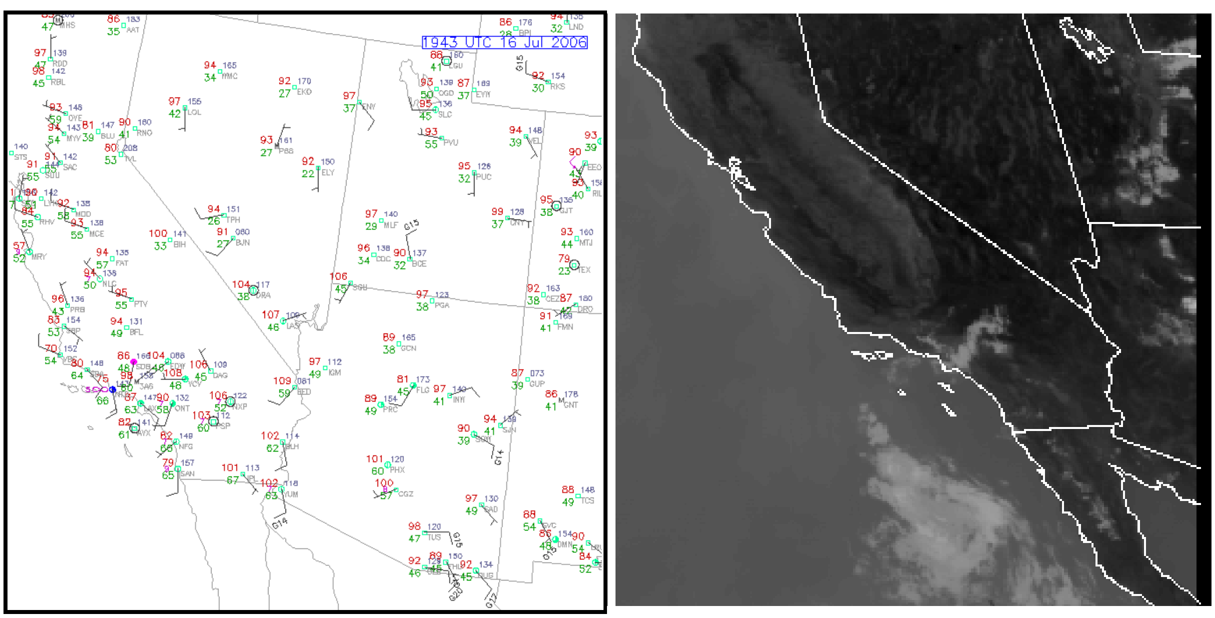

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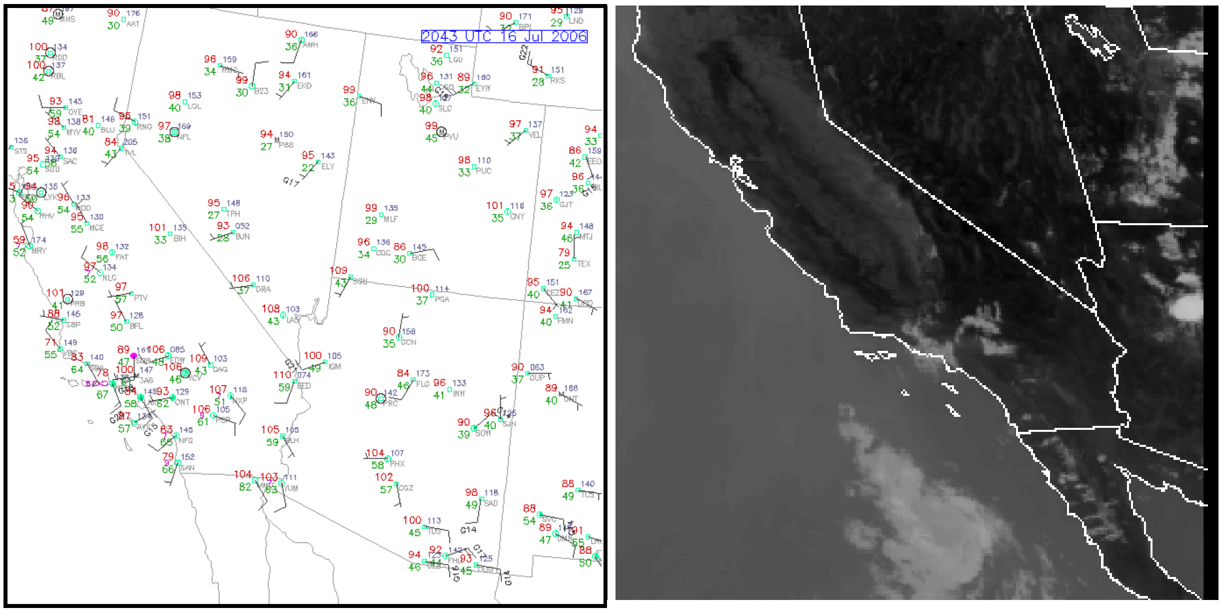

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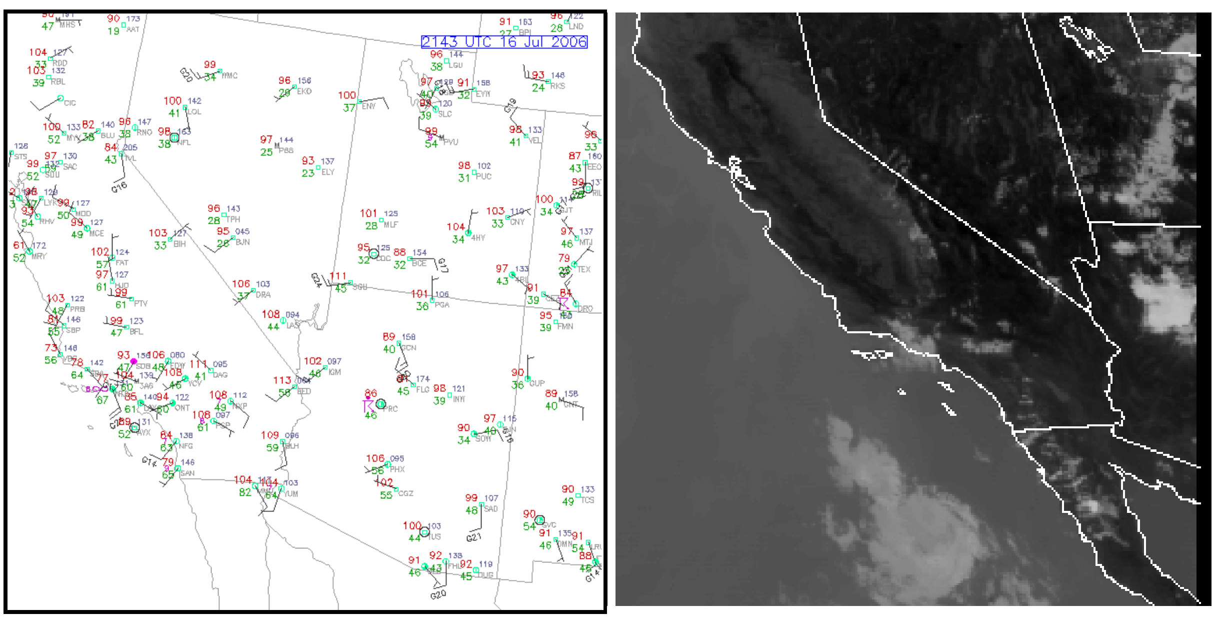

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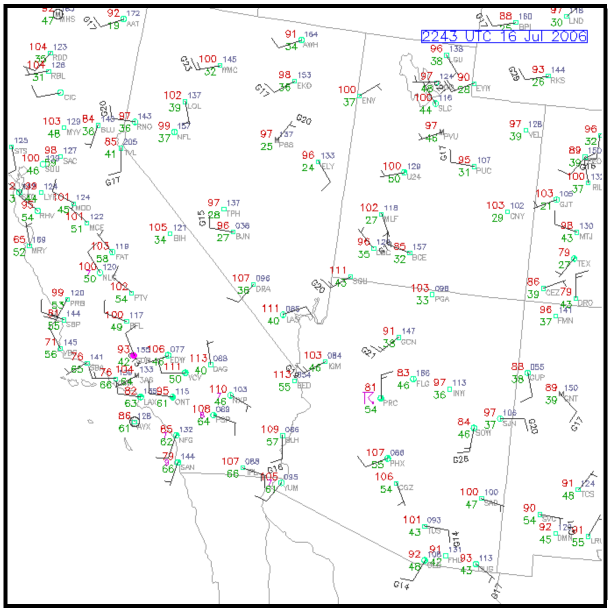

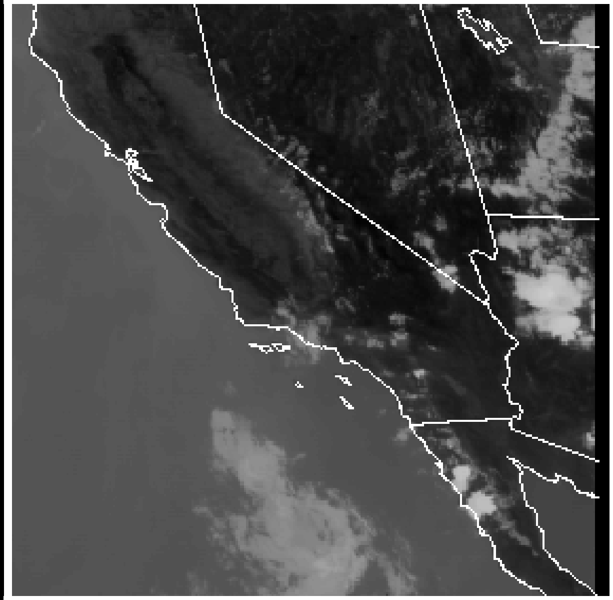

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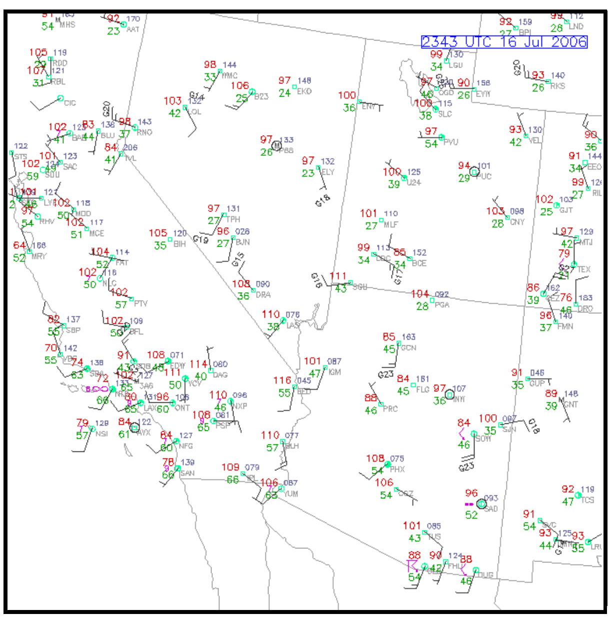

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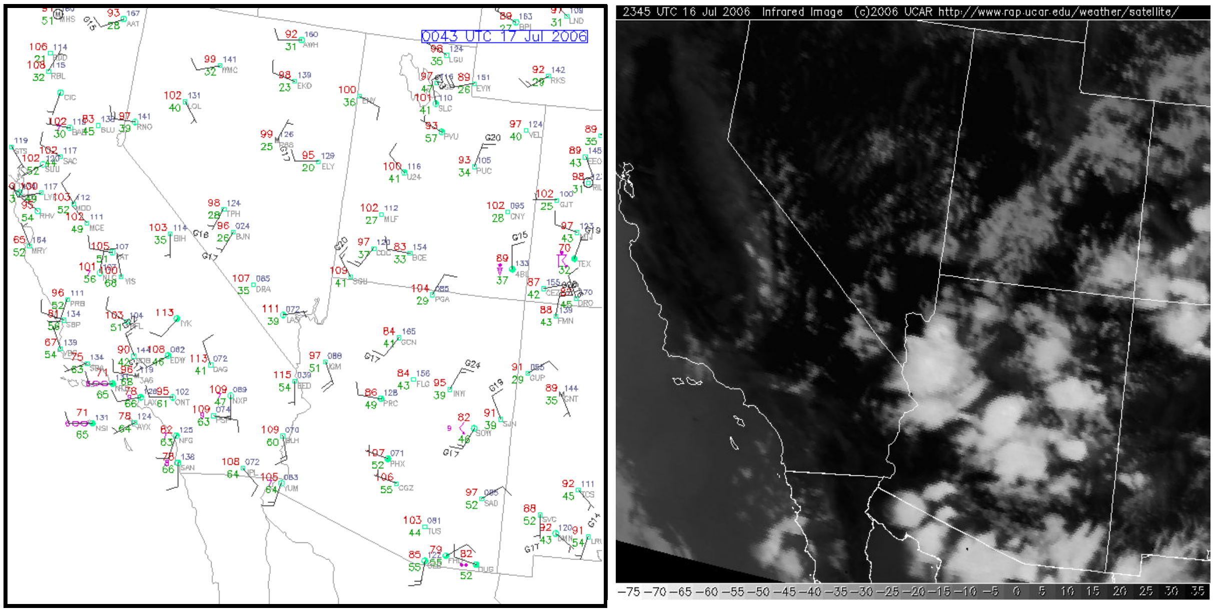

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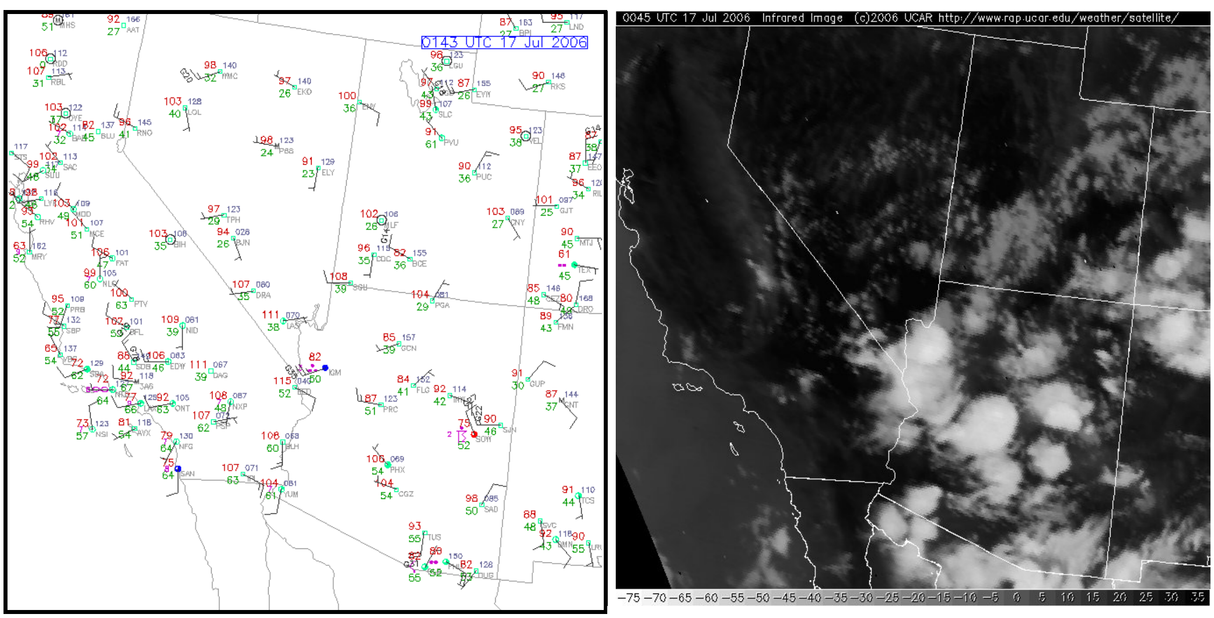

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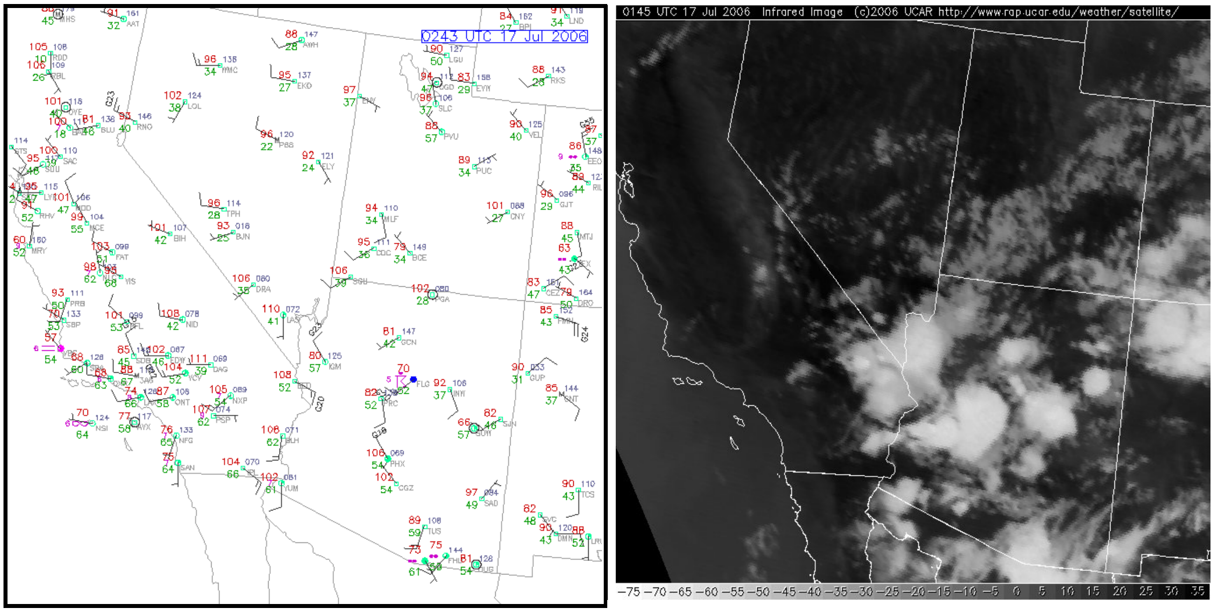

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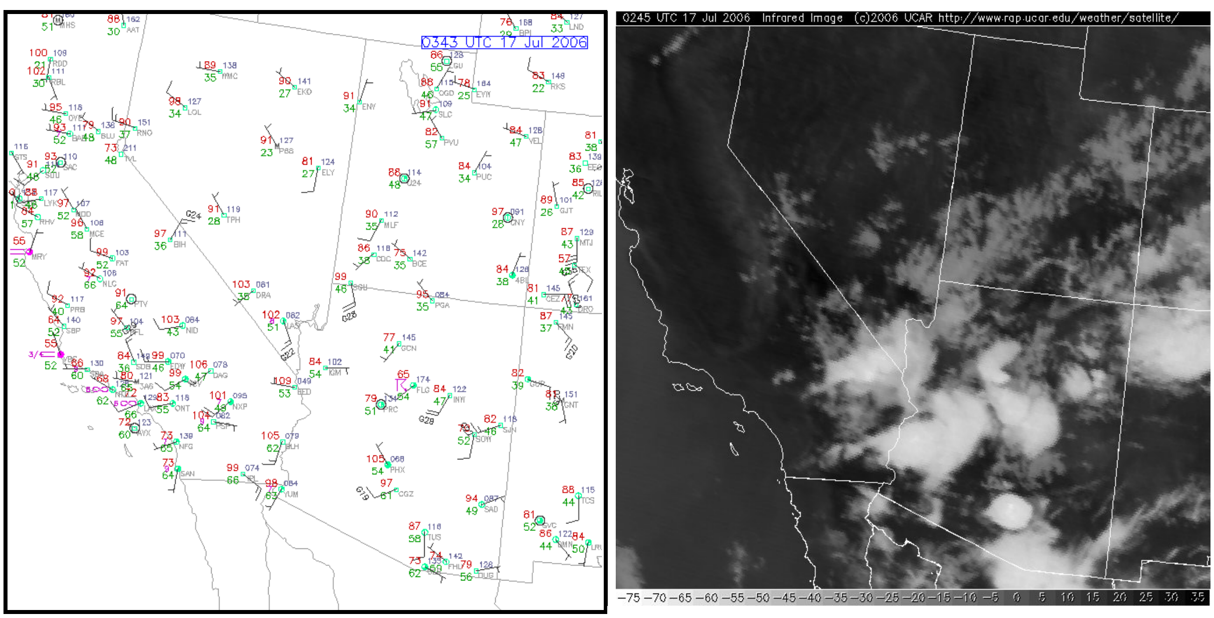

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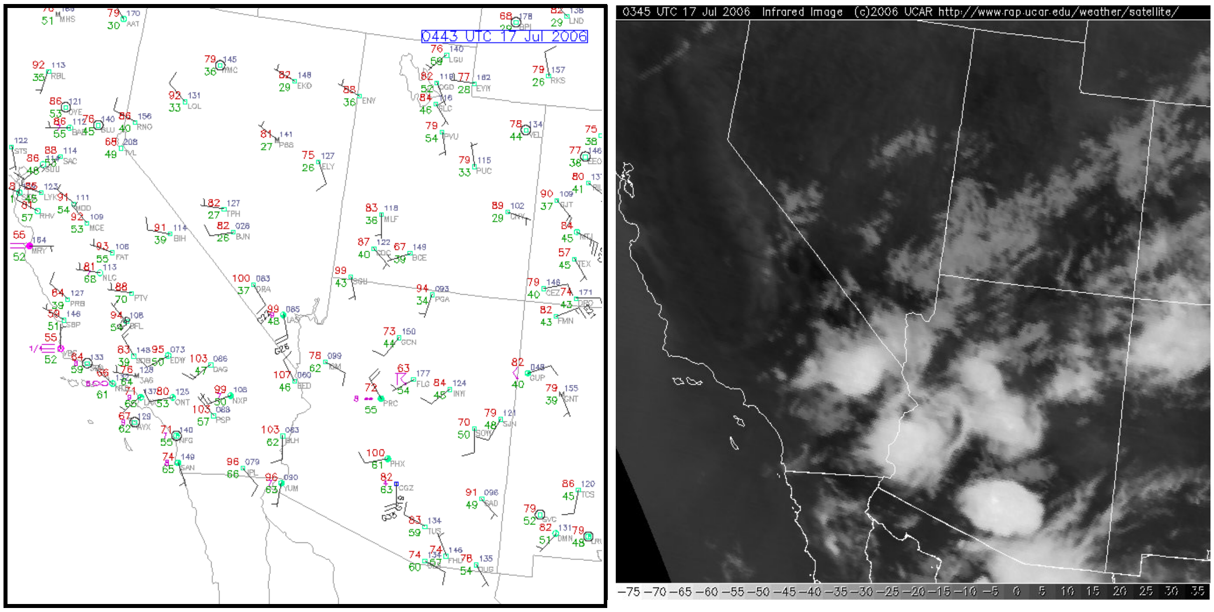

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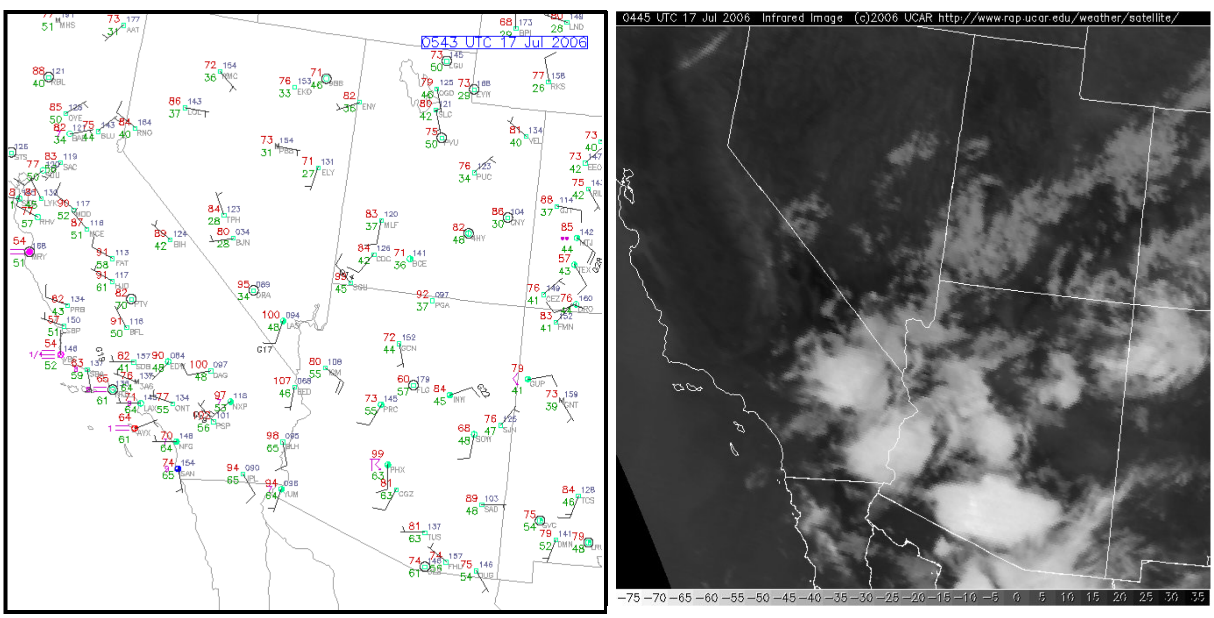

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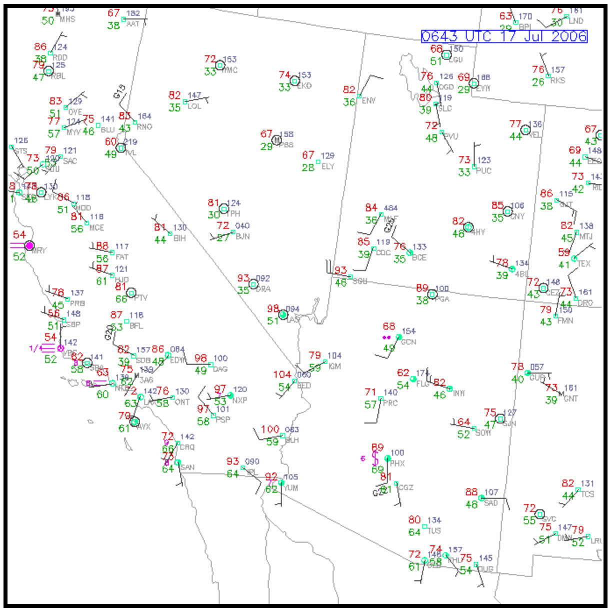

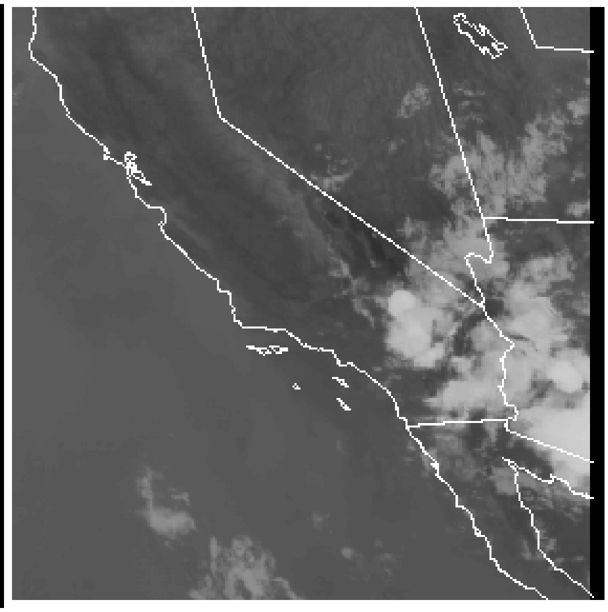

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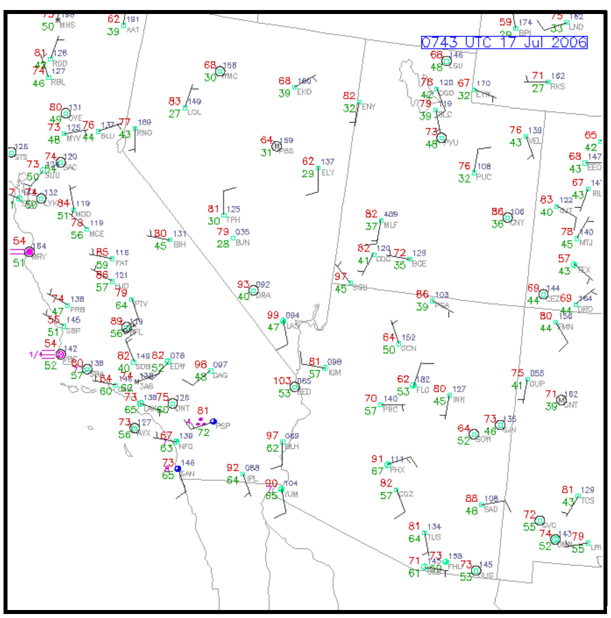

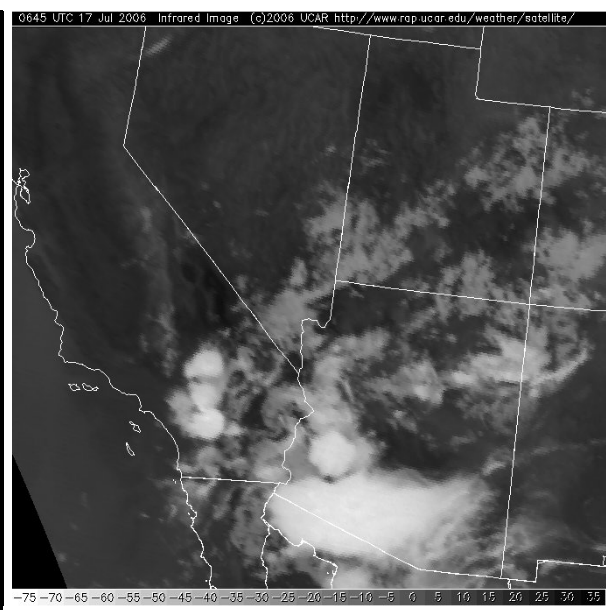

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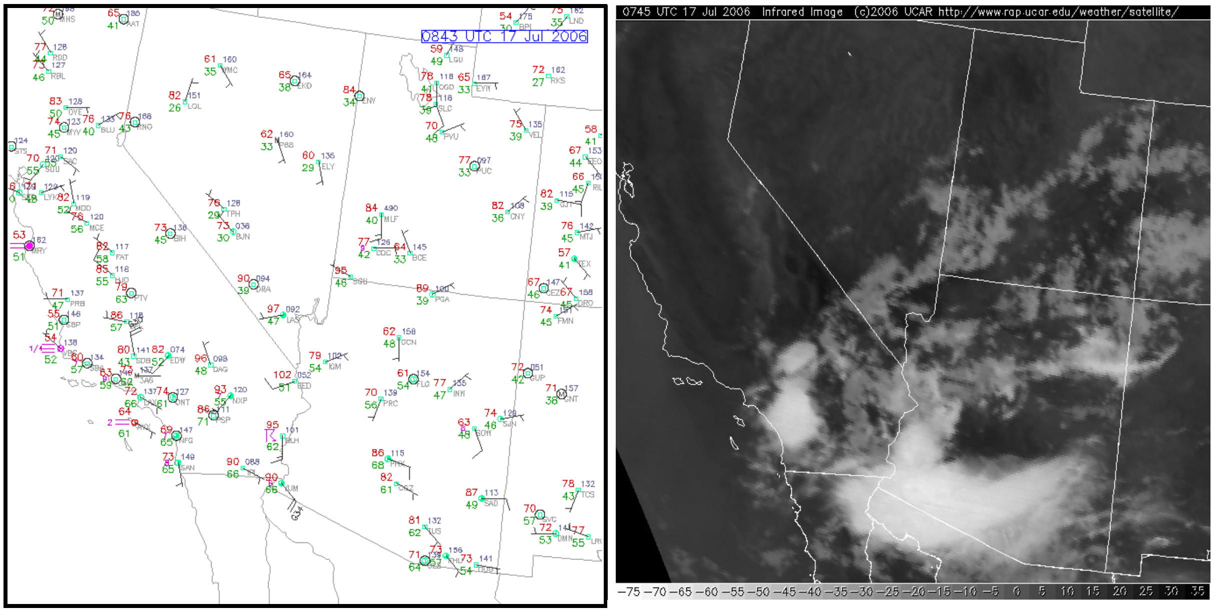

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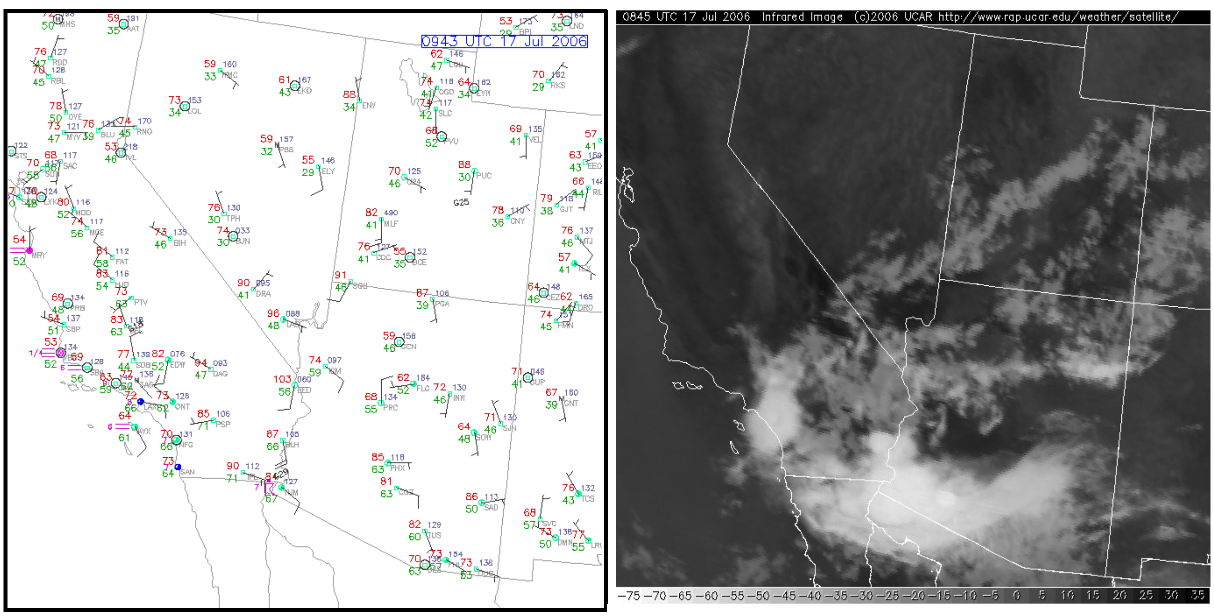

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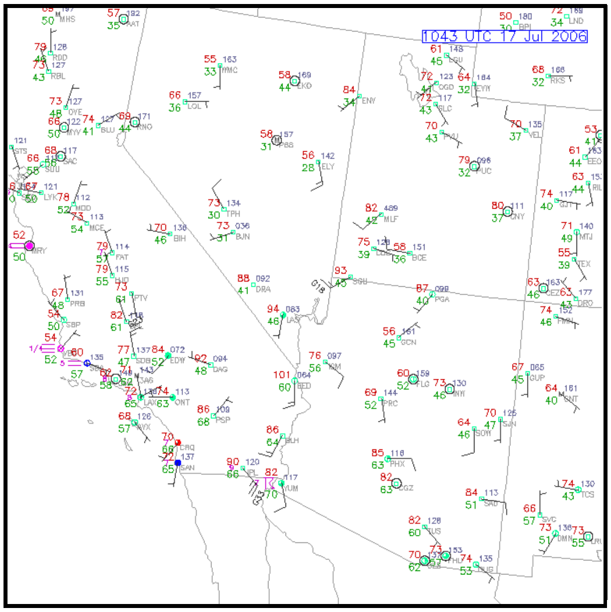

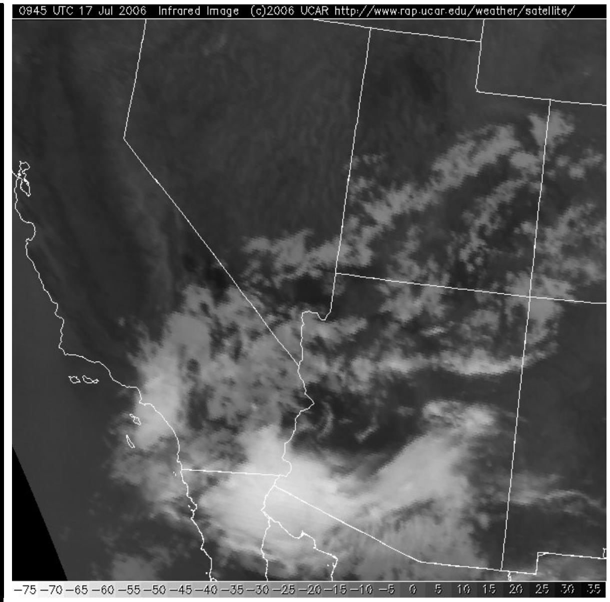

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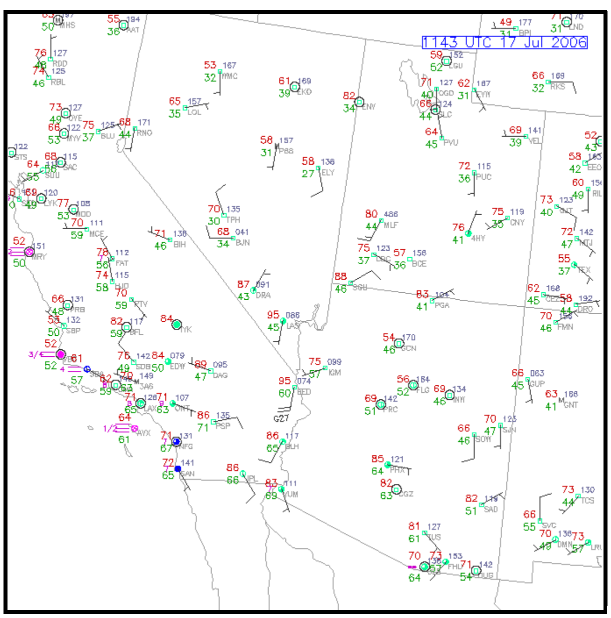

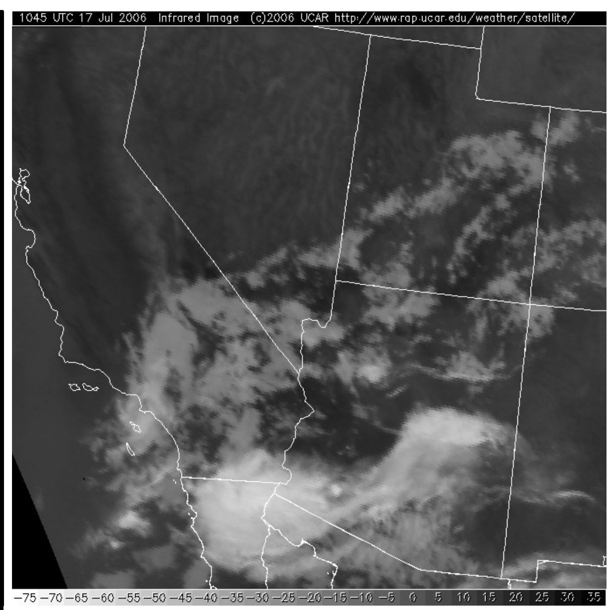

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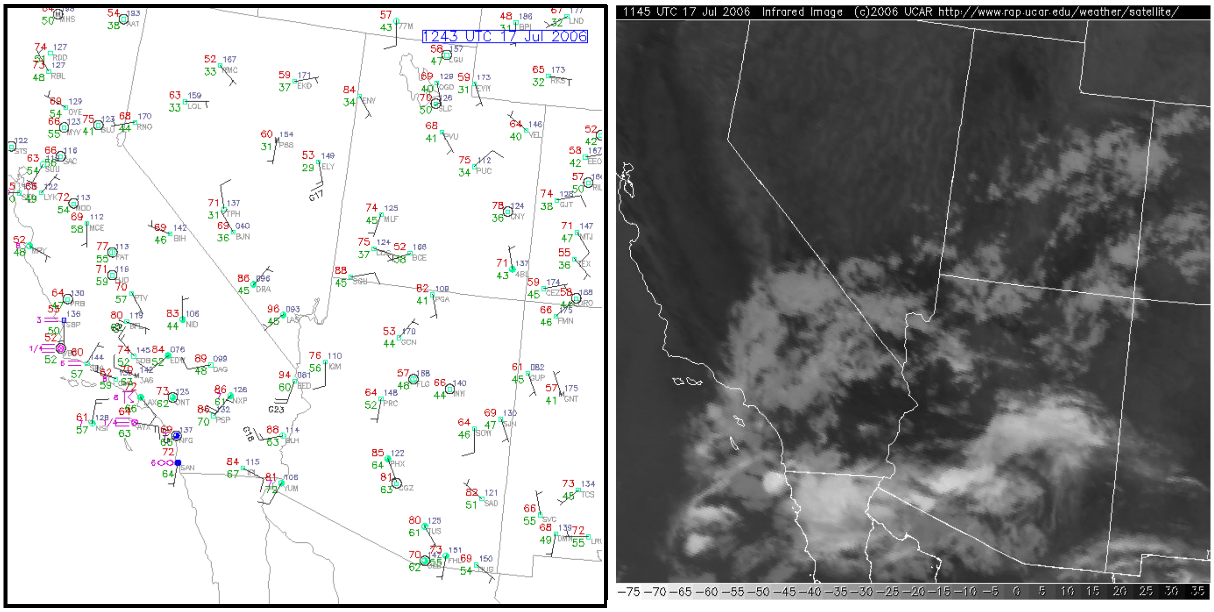

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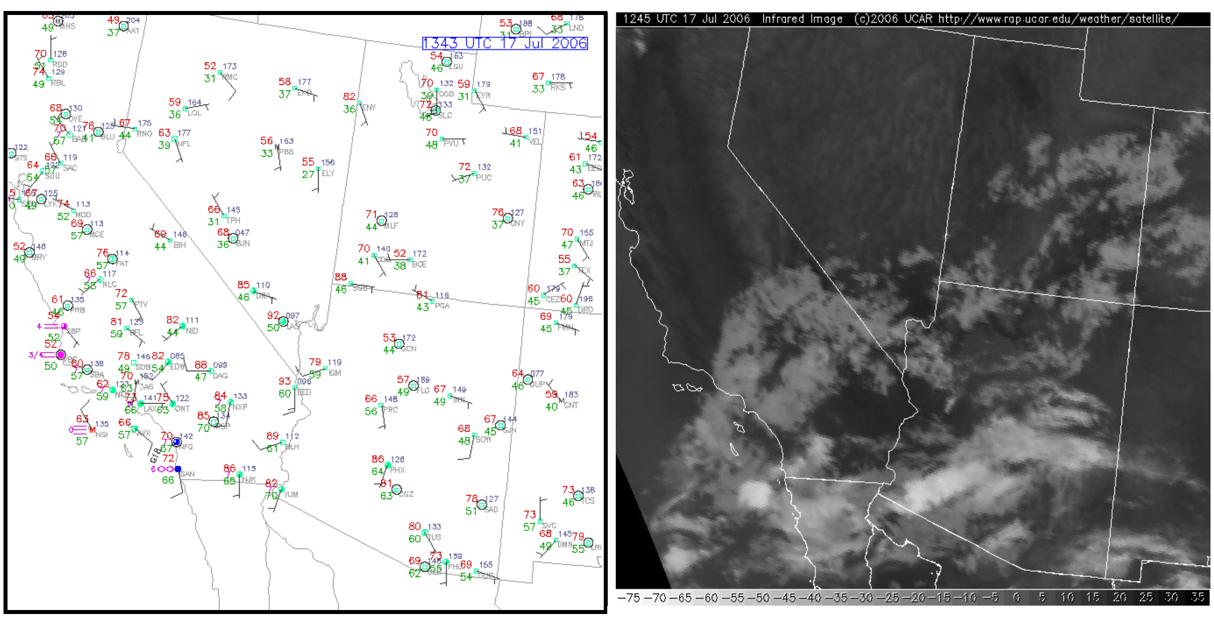

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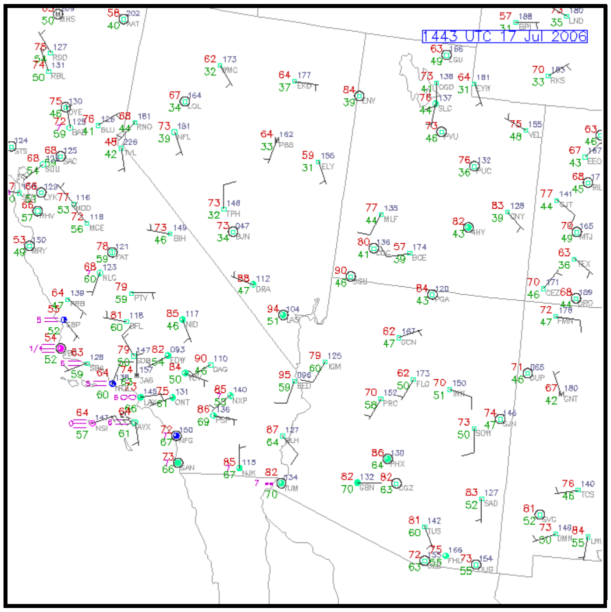

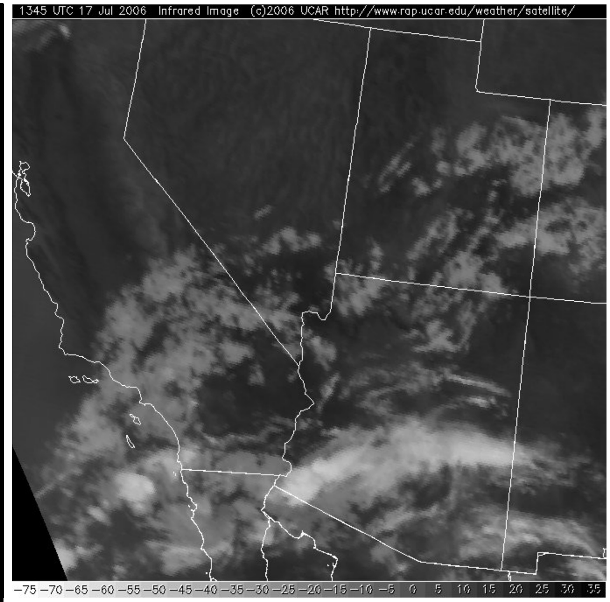

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